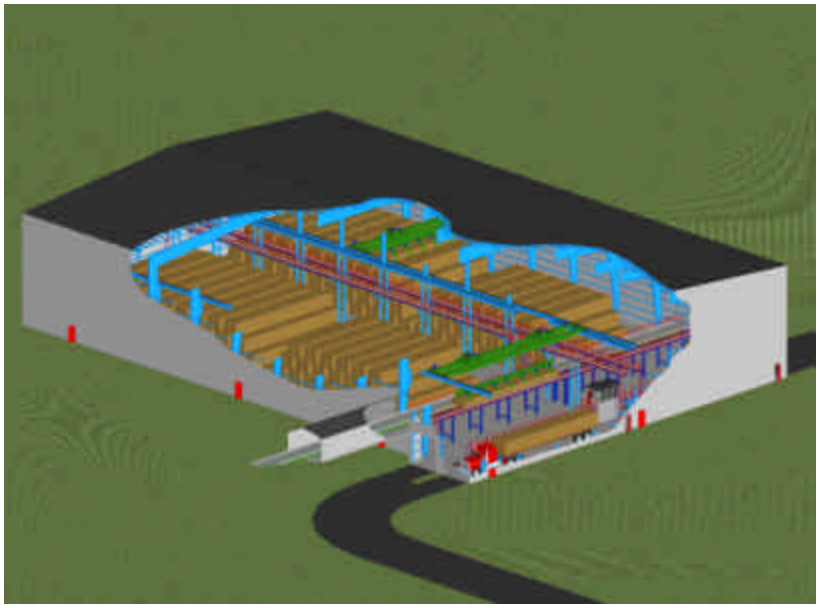
CHARITON VALLEY BIOMASS PROJECT

Design Package



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Chariton Valley
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July 12, 2002

Mr. Jim Spaeth
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Golden Field Office
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Dear Mr. Spaeth:

Chariton Valley RC&D, on behalf of partners cooperating on the Biomass Power for Rural Development sponsored Chariton Valley Biomass Project, would like to present to you the Design Package, Deliverable #1. This deliverable consists of an engineering design package and cost estimate that satisfies the deliverable definition in the current project statement of work.

As you are aware, the project's engineering team will continue to prepare the final design of modifications for a permanent biomass cofiring system at the Ottumwa Generating Station as per the project statement of work. It is anticipated that the final design will incorporate additional information developed by the engineering team that will substantially improve the technical, performance, and cost components of the Design Package Deliverable.

We are pleased to have this deliverable completed and believe that the design work summarized in the deliverable represents a significant step forward for our project. We anticipate that you will be equally pleased with the deliverable. We plan to have the remaining two deliverables completed by August 15, 2002.

Thank you,

Dora Guffey
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Table of Contents

Figures and Tables

Executive Summary

Background

CVRC&D has set a goal to cofire up to 25 tons per hour of switchgrass (Panicum vigatum) at the Ottumwa Generating Station (OGS) producing up to 35 MW of BioPower. This goal will provide both regional farming economic opportunities and positive environmental impacts. Tech-wise and Bradford Conrad Crow Engineering (BCCE) have designed a system based upon the European straw-fired cofiring design experience of Tech-wise to satisfy the cofiring goal set by CVRC&D. Their system design is detailed within this document.

OGS is located on a 375-acre site adjacent to the Des Moines River and is approximately seven miles northeast of Ottumwa, Iowa. The 725 MW coal-fired power plant, currently operated by Alliant Energy, went into commercial service in May 1981. The unit is designed for firing low sulphur Powder River Basin (PRB) coal in a pulverized coal boiler.

Experience to Date

From November 2000 to January 2001, a switchgrass-cofiring test occurred at OGS. The three objectives were to identify the effects of co-firing on boiler performance, measure any changes in emissions during co-firing, and gather information to improve the design of the switchgrass processing equipment. No significant changes were found in the boiler performance. Some emissions reductions were achieved especially in the SO_2 output. Several essential fuel handling and processing design issues were discovered such as dust created by the Eliminator and the de-baler and the surges in flow created by round bales (due to density variations). These issues were corrected by placing the system under negative pressure and only accepting rectangular bales.

The Studstrup Denmark plant is the basis of the design for the proposed switchgrass cofiring operation. In 1996, the Studstrup Power Station, a 150 MW_e power unit was converted for co-firing coal and straw. The system features automated crane storage and reclaim system, separate feed lines for the coal and straw, and the capacity for 22 tons per hour. The experience gained by Tech-wise in the cofiring operation at Studstrup is influencing the design for OGS.

Overview of Design and Process Flow

The design intent for OGS switchgrass operation is to have an availability of 90%, which represents an operating time of 7,884 hours per year. The switchgrass cofiring is designed for automatic operation from the central control room at OGS and is capable of long-term unattended operation. The process design makes use of proven equipment items for proven applications, wherever possible. Where conflict was found to exist between the safety requirements and requirements within the project, safety took precedence.

The plant is to receive large rectangular switchgrass bales (3’ × 4’ × 8’) with an average weight of 1000 lbs. These bales are delivered on semi-trailers with a body length up to

53 ft. and a total length up to 75 ft. These trucks will carry either 36 or 42 bales. The trucks will deliver the bales to OGS and will be unloaded within the storage building. This storage building has the capability to unload two trucks simultaneously using two overhead bridge cranes. The cranes either stack the bales in their respective bay or load them directly onto the twin bale chain conveyor for processing. The twin bale chain conveyor transports the bales to a transfer vehicle, which transfers the bales to the processing trains.

The chain conveyors placed before a de-baler control the switchgrass feeding to the boiler. Before the switchgrass is led into the de-baler, the twine holding the bale shall be removed. The switchgrass then falls from the conveyor – one pressing at a time – into the de-baler. The de-balers selected in this design are modified heavy-duty waste cutters. This de-baler type does not only shred the switchgrass, but it also reduces the switchgrass size to a certain extent. The pre-grinding in the de-baler is considered important for the final grinding of the switchgrass in the hammermill.

Under the de-baler, the shredded switchgrass is transported to a belt conveyor to further loosen the switchgrass and to meter the flow with the leveling rolls. The switchgrass is vacuumed from the belt conveyor through a stone trap, which removes the heaviest foreign objects. After the stone trap, the switchgrass proceeds into a hammermill where the switchgrass is milled into pieces smaller than 1 inch or 2 inches depending on the mesh size of the screen. From the hammermill, the switchgrass is fed from the screw conveyor bin through a rotary airlock to the pneumatic transport system. The transport system delivers the switchgrass to the boiler through a pipe to a burner feed system. Four milling lines feed into four parallel pipe sections.

1. Introduction

Chariton Valley Resource Conservation and Development (CVRC&D), Inc. has set a goal to cofire up to 25 tons per hour of switchgrass (Panicum vigatum) at the Ottumwa Generating Station (OGS) producing up to 35 MW of BioPower. Tech-wise and Bradford Conrad Crow Engineering (BCCE) have designed a system based upon the European straw-fired cofiring design experience of Tech-wise to satisfy the goals set by OGS. This design narrative will outline the preliminary design package prepared by Tech-wise and BCCE.

The design narrative will first describe the existing conditions at OGS. Second, an overview of the first cofiring test will be detailed. Third, the basis of the cofiring operation for OGS located in Studstrup, Denmark will be described. Then, the site-specific requirements for this project will be discussed which include details on the site, fuel, and climate. Next, a general outline of the process flow will be shown schematically and described. Finally, the general design requirements for each major storage and process equipment needed will be detailed.

In addition, this narrative supports the information provided within the appendices of this document. The preliminary engineering design documents, preliminary installation specifications, preliminary equipment specifications, and the soils report are all included within the appendices.

2. Existing Conditions at OGS

The OGS is located on a 375-acre site adjacent to the Des Moines River and is approximately seven miles northeast of Ottumwa, Iowa. The existing site plan showing the layout of OGS is located within Appendix 1 on drawing 732-1002. The 725 MW coal-fired power plant, currently operated by Alliant Energy, went into commercial service in May 1981. The unit is designed for firing low sulphur Powder River Basin (PRB) coal in a pulverized coal boiler.

The next few paragraphs will describe pertinent existing site and design project related information for the cofiring effort. First, the proposed site location for switchgrass storage and processing buildings will be detailed. Next, a discussion of the utilities and site amenities available for the cofiring operation will ensue. Finally, the availability of reusing existing equipment procured for the first cofiring test campaign will be explored for the permanent cofiring operation.

2.1 Proposed Site Location for Switchgrass Operation

Originally, both the switchgrass storage and processing center were to be located directly east of the main plant structure. This location was the site of the switchgrass storage and handling operations during the first cofiring test, which occurred between November 2000 and January 2001 (for further discussions of the cofiring test see chapter 3). In April 2002, Alliant Energy revealed their expansion plans to double their

existing fossil fuel power generation capacity in order to meet their growing customer demand. Their power generation capacity will be doubled with another plant structure approximately the same size as the existing structure. This new structure will be located to the east of the existing main plant in the same space that the switchgrass facility planned to occupy.

After this new development, the switchgrass facility has been moved to the far west of the OGS site next to the existing 3,000 ton capacity storage building. This area is approximately 1,000 feet west of the main plant structure and northwest of the existing cooling towers. Part of the area that the switchgrass operation intends to occupy is currently filled with spare parts and equipment, which include transformers and power poles. In addition, a small office building, also located on the proposed site, will remain. The new site location will be separated from the coal firing operations and will not interfere with any of the existing coal or ash truck traffic patterns.

2.2 Utilities and Site Amenities Availability

Roads

Currently, the path within the OGS site plan which services the 3,000 ton switchgrass storage building and the office building on the proposed site location are not paved. The main road just west of the proposed site location is outside the boundaries of OGS and is maintained by the state of Iowa. The parking area around the existing storage building is limited and is not currently paved.

Electrical Service

Electrical power is available from the main (13.8 KV) switch box service located near the southeast side of the proposed storage building. Another power line connection is available near the southeast side of the storage building. This additional power line runs to an abandoned substation and will be reused for the new facility if possible.

Plumbing and Mechanical Services

A possible connection to an existing 4" sanitary sewer line and a 2" water line are available near an abandoned guard house about 400 feet northeast of the processing building. No natural gas service is available for this project. Steam heat is available from the existing boiler and the closest connection point is about 700 feet away from the processing building. No potable (drinking) water is available near the proposed site location. The closest fire hydrant is located about 400 feet from the southeast corner of the proposed storage building.

2.3 Existing Process Equipment Availability

Table 2.1 Equipment List to be Reused.

Item	No.	Data
Blower for the pneumatic conveyor	2 pcs.	100 HP, TEFC, 3/60/230-460V motor, V-belt drive, mounted on a common base with inlet filter, inlet silencer & discharge silencer.
Burner nozzle	2 pcs.	According to drawing D-001 (page 2-24)

The equipment listed in Table 2.1 was used in the First Co-fire Test Campaign and is intended for reuse in the permanent operation.

3. Cofiring Test at OGS – November 2000 to January 2001

This chapter summarizes the activities of the switchgrass-cofiring test at OGS that occurred from November 2000 to January 2001. The summary makes reference to "Summary of Chariton Valley Switchgrass Co-Fire Testing at the Ottumwa Generating Station in Chillicothe, Iowa" by Wade A. Amos (NREL). The three main objectives of this cofiring test campaign were:

(1) Identify the effects of co-firing on boiler performance
(2) Measure any changes in emissions during co-firing
(3) Gather information to improve the design of the switchgrass processing equipment

First, the site location for the switchgrass operation will be discussed. Next, the process flow used for the cofiring operation will be detailed. In the process flow description, a discussion of the processing equipment, bale storage, and the transportation system. The results of the initial cofiring test and future scheduled cofiring tests will conclude this chapter.

3.1 Site Location for Switchgrass Cofiring Test

As mentioned in section 2.1, the switchgrass handling during the first cofiring test was performed in the existing switchgrass process building located directly east of the main plant structure. The switchgrass used for the test burns (cofiring test) was stored in the existing 125' × 250' storage building. This storage building is located about 500 yards west of the processing building. For a detailed layout of the existing site plan, see drawing 732-1002 located in Appendix 1.

3.2 Process Flow

The process flow schematic shown below in Figure 3.1 was used during the test. This section will describe the equipment used in the test burns, the bale storage methods, and transportation system used to deliver the switchgrass to OGS.

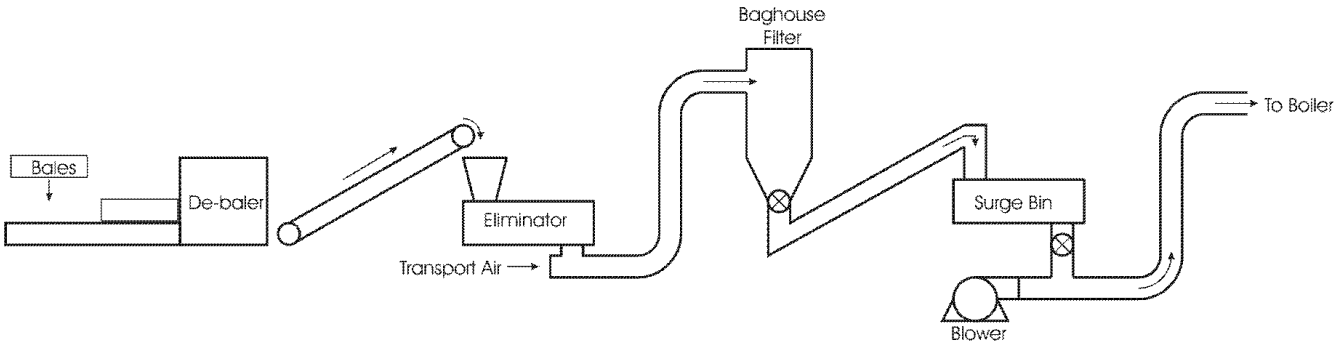


Figure 3.1 Test Cofire Flow Schematic

3.2.1 Feed-processing Equipment

From the storage within the processing building, the bales were placed by means of a telescoping fork truck onto a platform with a drag-chain conveyor feeding a de-baler. After being placed on the platform, the twine was cut with an axe and manually pulled off the bale from the top. The de-baler consisted of a rotating drum mounted with teeth, which tore the switchgrass off the end of the bale, one layer at a time. The switchgrass was then pushed out of the side of the de-baler with a high-speed screw conveyor.

The switchgrass exiting the de-baler was discharged onto an air knife. The air knife was designed to allow heavy material to drop out through the flow of air, while the lighter switchgrass would be blown onto a belt conveyor taking it to the "Eliminator" grinder. The Eliminator grinder consisted of two intermeshing rotating shafts, which would throw the material around inside the unit, breaking it up. At the outlet of the Eliminator, a duct from the bag house pulled a partial vacuum on the exit stream. Additional transport air was admitted to the duct through an adjustable slide gate located under the Eliminator.

The airflow from the Eliminator was combined with the flow from several other smaller dust collection lines before entering a bag house filter. The material was removed from the bag house using a rotary valve. This material was dropped onto a totally enclosed tube conveyor, which consisted of a belt lying in a curved trough, driven on the upper end. The bag house was located outside of the switchgrass building because of its height, so the tube conveyor passed back inside through the wall of the switchgrass building.

The bag house tube conveyor dumped into a surge bin, which had two pairs of co-rotating screws in the bottom. Each pair of screws fed a rotary airlock, dumping into a pneumatic transport line.

The pneumatic transport system consisted of twin carbon steel pipes; each fed by a positive displacement rotary lobe blower. After entering the power plant, the pipes went to opposing corners of the east fireball. Foster Wheeler switchgrass nozzles injected the switchgrass between the third and fourth rows of coal burners from the bottom. A slide gate at the boiler nozzle was included for positive shutoff of fuel during boiler trips.

3.2.2 Bale Types and Storage

A 12,000 sq.ft. (1,100 m^2) building was constructed behind OGS to house both the feed processing equipment and to store approx. 300 tons (272 tons) of switchgrass. The original hope was to use 3' × 3' × 8' (0.9 × 0.9 × 2.4 m) bales, 3' × 4' × 8' (0.9 × 1.2 × 2.4 m) bales and 6' (1.8 m) round bales during switchgrass testing. However, it was quickly found that the round bales, because of their variation in density between the outside layers and the core, could not be fed evenly into the equipment. For that reason, testing

was restricted to the 3' × 3' × 8' and 3' × 4' × 8' bales, which weighed on average 700 lbs. (318 kg) and 1,000 lbs. (454 kg), respectively.

Bales were delivered to OGS by flatbed trailer, with 54 (3' × 3' × 8') or 36 (3' × 4' × 8') bales per truck. The bales were normally unloaded at night or in the early morning so that the fork truck driver was not required to both unload bales from the truck and maintain the feed processing system. The bales could be stacked 6 high (18 ft. or 5.5 m) in the storage area. Three 3' × 3' ×8' or three 3' × 4' × 8' bales could be handled at a time using a telescoping fork truck with a special bale pusher mounted on the fork.

3.2.3 Processing Equipment

The bales were placed onto a platform with three 3' × 3' × 8' bales side-by-side or with two 3' × 4' × 8' bales side-by-side with a drag-chain conveyor feeding a de-baler. After being placed on the platform, the twine was cut with an axe and manually pulled off the bale from the top. The twine had a tendency to wrap around the rotating parts in the feed-processing system or lodge in the bag house, so it had to be removed whenever possible.

The bales would be pulled into the de-baler by means of a drag-chain conveyor. The de-baler consisted of a rotating drum mounted with teeth, which tore the switchgrass off the end of the bale, one layer at a time. During testing, the teeth on the de-baler were periodically sharpened. The switchgrass was then pushed out of the side of the de-baler with a high-speed screw conveyor. Because the entire feed-processing system was operated in a starved-feed mode, varying the drag-chain conveyor speed was the primary method for controlling the switchgrass flow to the boiler.

The air knife blower was designed for entrained solids flow, so it did double duty controlling dust by pulling a suction on a hood over the both the air knife and the de-baler discharge. The air knife worked well at low feed rates, separating corncobs, rocks and other material from the lighter switchgrass, but at higher feed rates, the mat of material was too thick for any separation.

Because the De-baler-to-Eliminator Conveyor belt was smooth, there was very little friction between the belt and the switchgrass and there were limits to the angle of inclination of the conveyor. In the final design, it will be important to have the ability to adjust the alignment of the belt conveyor and the inlet chute for obtaining the proper trajectory of the material into the grinder.

Unlike a hammermill that will be proposed for the final design, the Eliminator had no outlet screen for classifying the material size. The extent of grinding was entirely dependent upon the residence time and the amount of material passing through the unit. As the residence time increased, the particle size went down.

The velocity through the suction line leaving the Eliminator was estimated at about 30 ft/s (9.1 m/s), which was probably lower than it should have been. At this velocity, a

slight decrease in transport air to the Eliminator discharge would lower the velocity enough that the nodes leaving the Eliminator would collect in the bottom of the tube, almost filling it in just a few minutes. This pointed out an important lesson for the design of switchgrass systems: the minimum transport velocity must be set to transport the nodes, not the bulk switchgrass, which is lighter and less dense than the nodes. This characteristic of the transport system illustrated that it might also be possible to selectively remove the nodes, if desired, and it allowed the team to get relatively clean fractions of nodes for testing.

During the testing there were some problems with the cleaning of the baghouse filter, which resulted in discontinuous flow from the conveyor to the surge bin and inconsistent particle size distributions. The baghouse filter design was not a problem; these problems arose due to the lack of oil within the gearbox. After rebuilding the gearbox and replacing the screw conveyor with a "tube belt conveyor", the transport operated without any problems.

The switchgrass level tended to build up in the surge bin. Trying to move the stack of material forward toward the outlet would move the whole pile of switchgrass up against the front wall, causing the screws to bind and trip out. It was necessary to run the surge bin with the feed screws on maximum so no significant level of switchgrass was built up in the bin. Due to a dividing wall in the surge bin, an uneven distribution of the flow between the two burners was seen.

By keeping all of the equipment downstream of the Eliminator under a slight negative pressure, dust levels were minimal. The rotary airlocks under the surge bin caused continual problems due to the build-up of dust between the ends of the rotating pockets and the stationary valve housing. This created enough friction to trip out the airlock drives on overload. In some airlock designs, an air purge is used to blow out any dust that builds up on the ends. Still other airlocks are designed without an end plate, so this build-up does not occur. Discussions with other airlock manufactures indicated that the rotary valves might not have been of the proper design for this application.

Bulk switchgrass densities were measured at various points in the system, which will help with the redesign of the feed-processing system for continuous operation. The system used for the first round of co-fire testing required four operators and typically ran for just one shift per day. The second round of switchgrass testing will evaluate the performance of a system designed to run continuously with minimal operator attention.

3.2.4 Transportation System

A design problem with the transport lines was that no expansion joints had been included for upward contraction of the boiler when the boiler was shut down. A rigid connection between the compressors and transport line has to be avoided in order to decrease the stress on the transport lines due to vibration.

The positive displacement blowers presented some problems because the air intakes were undersized. The cold weather and the dust that had collected on the air filters over a couple of weeks of testing caused too much pressure drop on the intake side of the compressors. The vendor believed that the air intakes had probably been ordered based on flange size and not based on the airflow, since good design practice would have included a larger safety margin on the airflow.

3.3 Results from Cofiring Test

From November 30, 2000, through January 25, 2001, the switchgrass team co-fired 1,269 tons of switchgrass at rates up to 16.8 tph (tons per hour), representing about 3% heat input to the 725 MW power plant. The qualitative results from the three objectives (boiler performance, emissions, and switchgrass fuel handling) of the cofiring test are listed below.

Boiler Performance

- The small amount of air entering through the pneumatic transport system did not affect the boiler oxygen controls.
- At switchgrass flows over 12 tph, it was possible to see the coal flow change in response to the addition of switchgrass fuel.
- Inspections immediately after shutdown showed no unusual slag or buildup in the boiler.
- The boiler capacity was not de-rated because the switchgrass was fed by an independent injection system.

Emissions Changes

- During this test campaign the NO_x emissions did not change significantly and may have gone up slightly when co-firing, but were well within the normal range.
- A comparison of the SO_2 during co-firing with the baseline indicated a reduction greater than that just from the fuel substitution.
- Although carbon monoxide emissions were recorded during the stack testing, the results could not be used because operational problems caused carry-over of unburned material out of the boiler, causing abnormally high CO emissions.

Switchgrass Fuel Handling - Lessons Learned

In addition to the fuel handling issues addressed in sections 3.2.3 and 3.2.4, the following material handling lessons were learned.

- Round bales caused difficulties feeding because of the difference in density between the outer layers of the bale and the inner core.
- The switchgrass leaving the de-baler has an extremely low density of 1.3-4.0 lb/ft^3 (21-64 kg/m^3) and the mat of material might be a foot (30 cm) or more in height on the belt conveyor leaving the de-baler.

- The switchgrass pieces leaving the de-baler were still 1-2 feet (0.5 m) in length and therefore were prone to bridging.
- The switchgrass after grinding would not only settle quickly to approximately 90% of its initial volume leaving the Eliminator, but it actually had a higher density than the original switchgrass bales.
- The most notable feature of switchgrass is the dust. Even the de-baler operation created high dust levels in the building. It is important to keep the equipment under a negative pressure so no dust leaves through the cracks between equipment.
- No problems occurred in transporting the switchgrass through the pneumatic transport lines.
- The boiler nozzles appeared to work well. After shutdown, the OGS staff noticed no buildup around the burners from firing switchgrass.

3.4 Future Scheduled Tests and Associated Goals

The second cofiring test campaign is to use the initial cofiring system test rate of 12.5 tph and burn up to 6,000 tons of switch grass. The third cofiring campaign is to look at long-term boiler effects with the goal of co-firing switch grass for some 2,000 hours at the 12.5 tph feed rate. This testing would answer questions about corrosion and fouling in the boiler. The size of the final commercial system will be sized for a capacity of 25 tph.

4. Basis of Design for Project at OGS – Studstrup, Denmark plant

To meet the commitments to CO_2 abatement and large-scale biomass applications, the Danish power company Elsam has carried out a comprehensive program developing coal and biomass technologies over the past 12 years. One of the options considered was co-firing straw at existing pulverized coal plants. To assess the prospects of this technology, a 150 MW_e power unit at Studstrup Power Station was converted for co-firing coal and straw. Subsequently, a 2-year demonstration program was performed from January 1996 to February 1998.

4.1 Plant Description

The Studstrup Power Station, Unit 1 (MKS1), consists of a 380 MW_{th} PC boiler and a 152 MW_e condensing turbine. The boiler is a two-pass wall-fired boiler operated since 1968. The boiler is equipped with 12 conventional axial swirl burners, four burners at three levels. No flue gas cleaning is provided, except for an electrostatic precipitator.

During 1995, MKS1 was converted into co-firing coal and straw for demonstration purposes. The plant was taken out of operation in 1998 primarily due to excess capacity in the system. In late 2001, the straw facilities were re-commissioned and Studstrup Unit 4 is now co-fired.

4.2 Boiler Modifications

The medium-level burners have been converted into combi-burners. Modification of the burners involved few changes. The oil lance and flame detectors were relocated in order to clear the core of the burner for pneumatic straw feeding.

The boiler has been mounted with probe gates at six positions to provide access for in-situ sampling and measurements along the gas route through the boiler. Specially developed water- and air-cooled probes were used for the measurements.

4.3 Straw Processing

The straw processing equipment consists of a storage facility and a processing building erected at the southwest corner of the coal yard. The distance from the processing equipment to the burners at MKS1 is approx. 1,500 ft (140 m).

Transport of straw to Studstrup Power Station was accepted by the local authorities on normal workdays from 7:00 a.m. to 6:00 p.m. and on Saturdays from 7:00 a.m. to 2:00 p.m. If a high straw share was to be fired in weekends, this meant that the storage should be able to hold a large capacity.

The storage is split into two sections, with a capacity of 560 Hesston bales each. The bales are stacked in six layers and have a standard dimension of 47 in. $\times$ 51 in. $\times$ 94.5 in. and a typical weight range of 990-1100 lbs (450-500 kg). The bales are delivered to Studstrup Power Station by truck.

An overhead bridge crane unloads the trucks. The crane unloads 10 or 12 bales - one course - in the same procedure. During unloading the bales are weighed, the moisture content is measured by use of microwave techniques - and the data is stored on a central logistics computer.

Either the straw courses are transferred to a vacant position in the straw storage or they are transported to the processing equipment by means of a twin bale chain conveyor situated at the end of each storage bay. The processing plant consists of four parallel lines each with a capacity of handling 5 tons of straw per hour, see figure 4.1 for the flow schematic typical for each of the four lines.

The straw flow to the boiler is controlled by chain conveyors situated before a de-baler. Before the straw enters the shredder, the twine holding the bales together are cut and removed. From the conveyor, the layers of the bale are falling into the de-baler. The de-balers are modified heavy-duty garbage disposal machinery. After the de-baler, the straw flow is made uniform on a belt conveyor. The straw is then vacuumed through a stone trap - removing the heaviest foreign particles – and then into the hammermill where the straw is ground into pieces shorter than 1 or 2 inches depending upon the screen.

From the hammermill, the ground straw is fed through an airlock. After the airlock, the straw is pneumatically transported in four parallel lines for 1,500 feet (450 meters) before it enters the boiler.

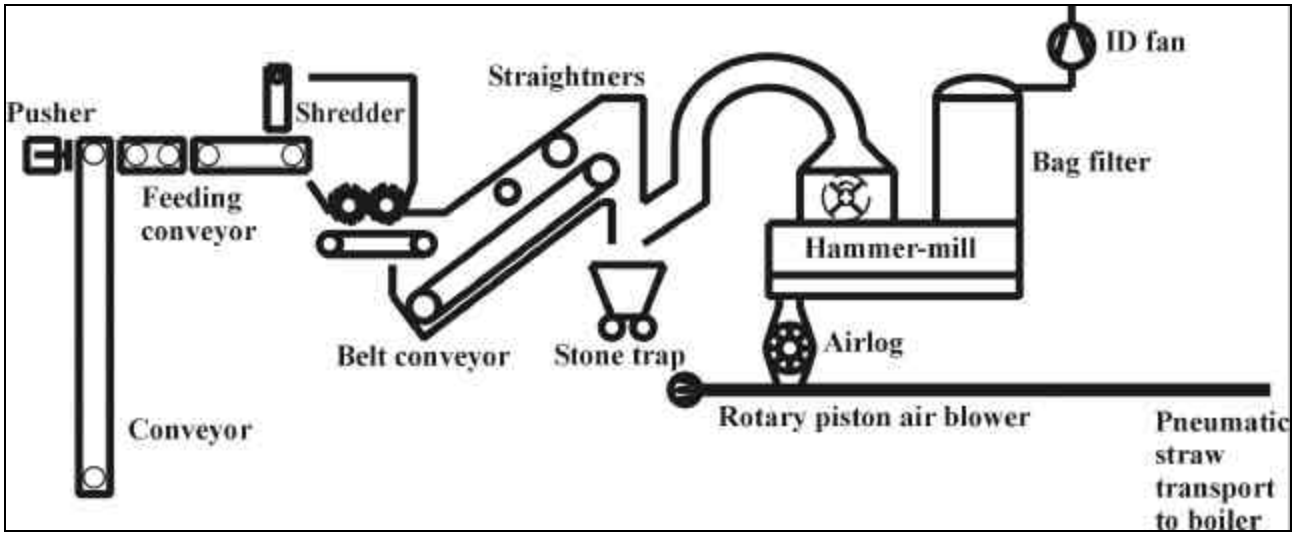


Figure 4.1 Principle of straw line on Studstrup power station, Unit No. 1.

Figure 4.2 Unloading straw at Studstrup Power Station.

Figure 4.3 Feeding conveyor, twine remover and debaler.

4.4 Operating Experience

Straw Processing

The operation of the straw processing plant was not problem-free. The extensive processing of the straw implies that the many links of this process need to function optimally as a system to ensure a high availability. Since many of the suppliers for the project had never worked with straw as a media, the first half of the project implementation was characterized by various modifications to the plant to raise the availability to an acceptable level. This experience at Studstrup shows the importance of commissioning the plant properly before starting a test period when establishing new and innovative plants.

In the beginning of 1996, there were many problems with moist straw. The straw was characterized by being composted "dry" straw from the harvest of 1995, which had been stored outside until delivery. This meant that there were local spots with a very high moisture degree or “wet lumps”. These “wet lumps” caused problems especially in the hammermill, which tripped out owing to overload and because of plugging of the pneumatic transport pipes. The transport pipes were blocked because of an inappropriate design of their bends, which had a rectangular cross section to obtain a replaceable back plate. During the spring of 1996, the bends were replaced by bends with a circular cross section. Apparently, this meant that it is now possible to accept a few wet spots to the straw bales.

From June to November 1996 a corrosion test of a boiler was performed with a straw share of 10% corresponding to a fired straw amount of about 9 tph. During fall-out of the test boiler, the remaining straw processing lines handled excess capacity to maintain the desired amount of straw. For quite some time, one of the straw processing lines was not working owing to a fire in the hammermill caused by sparks from a piece of metal

hidden in a lump of straw. During the test, which lasted for about 3,000 hours, an average straw share of 9% was obtained.

The corrosion test with a 20% straw share was also - though not as significantly - characterized by the difficulty of obtaining the desired feed rate of almost 5 tph per straw processing line. This was primarily owing to capacity problems with the straw shredders. For a long period, the availability of the shredders was very poor due to problems with their gearboxes. These problems are not related to the straw, but to a defective construction from the supplier.

Figure 4.4 shows the straw share and boiler load of the 20% corrosion test. From March to the middle of October 1997 there were 3,012 operating hours of firing straw and an average straw share of 16.2%.

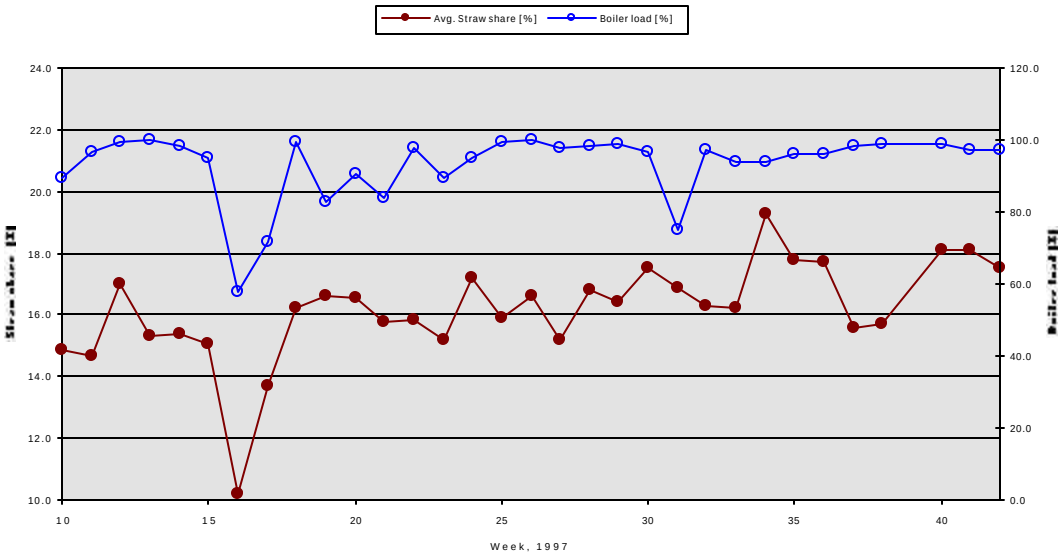


Figure 4.4: Straw share and boiler load.

If the obtained straw share of 16.2% in figure 4.4 is seen as an indication of the availability in relation to the objective of a 20% straw share, this quite simplified observation results in an availability of 81%. If the availability from week 24-42 is calculated as the ratio between the obtained straw share and the intended straw share, the result is 85%. It should be noted that this load has not been corrected to obtain a higher straw share.

Looking at the first period of the 20% long-term test, evident commissioning problems were connected with the first long operating period with an intended 20% straw share. The last period of the test produced the expected results from firing approx. 5 tph per straw processing line (between 16% and 20% straw share).

One of the most important limitations of the straw processing plant, preventing the obtainment of a higher straw share, is the capacity of the shredders. The shredders tend

to not loosen the straw adequately when the line is working with a high load. The result is that lumps of straw end up in the hammermill and cause it to trip out on overload. An important parameter in this connection is also the feeding of the shredder. From the end of the feeding conveyor, the straw is delivered one press blow at a time into the shredder. However, this has been difficult to obtain, and when more press blows fall into the shredder at one time, shredding is reduced.

Minor alterations to the plant at MKS1 can possibly solve some of these problems and can improve the availability. The possibility exists to obtain an availability of 90% for this plant, whereas the availability of future plants would be even higher.

5. General Design Requirements for OGS

5.1 Plant Design Life and Availability

The plant is designed for a minimum functional life of at least 20 years. The plant shall achieve an availability of 90%, which represents an operating time of 7,884 hours per year. The 10% unavailability is comprised of scheduled downtime for maintenance (600 hours per year) and unscheduled down time.

5.2 Operating and Maintenance Philosophy

Operations
The plant - other than the facilities for reception of switchgrass bales (the storage barn) - shall operate automatically from the central control room at OGS and shall be capable of long-term unattended operation. The plant shall only be manned during day shifts (7:00 a.m. to 3:00 p.m.).

Maintenance
It is expected that only very limited maintenance staff will be employed at the plant; therefore maintenance tasks carried out under normal circumstances will be preventive maintenance, light repairs, and cleanup. The plant intends that major repairs and annual maintenance shutdowns will be performed by contractors.

5.3 Design Philosophy

The design of the storage described in detail below has proven to operate effectively and with a high availability at several power plants in Europe. The design of the processing of switchgrass shall benefit from the experience gained at the first test campaign firing switchgrass at OGS (chapter 3) and the co-firing facility at Studstrup Power Station, Denmark (chapter 4).

The process used in each system in the plant consists of equipment items proven in configurations, wherever possible. No piece of equipment shall be proposed or incorporated into the design that has not been used before in a similar combination of

process or design. Well-proven equipment is preferred when possible. Equipment with limited operational experience may be proposed if necessary or advantageous.

5.4 Climate Data

Climatic data for the site are given below.

Wind velocity:	Average velocity	:	12.7 mph (20.5 km/h)
Air temperature:	Maximum recorded	:	104°F (40°C)
	Minimum recorded	:	-31°F (-35°C)
	Highest monthly average	:	75.9°F (24.4°C)
	Lowest monthly average	:	23.1°F (-4.9°C)

5.5 Dust Emissions to Atmosphere

The concentration of particulate matter released to the atmosphere from non-combustion sources shall not exceed 50 mg/Nm^3.

5.6 Requirements Relating to Safety

The design of the plant shall comply with the requirements given in this section that relate to safety. Where any conflict is found to exist between the safety requirements and requirements stated elsewhere in the project specification, the safety requirements take precedence.

When handling switchgrass, some dust will be released to the surroundings. Exposure to dust can cause respiratory disorders to the people working in the respective areas and therefore the waste of switchgrass particles due to processing and transporting must be minimized.

5.7 Fuel Specifications

5.7.1 Size of Bales

The plant is to receive large rectangular switchgrass bales, the so-called 3' × 4' × 8' (91.4 cm × 121.9 cm × 243.8 cm) with an average "as-received" weight of 1000 lbs (454.5 kg). The baling at the farmers will be done by means of two types of baler equipment. The bale dimensions obtained from these types are listed in Table 5.1.

Table 5.1 New Holland and Freeman bale dimensions.

Bale type		**New Holland**		**Freeman**	
	Unit	**Design (nominal)**	**Variations**	**Design (nominal)**	**Variations**
Width	inch	48	46 – 50	46	44 – 48
Height	inch	34	32 – 36	38	36 – 40
Length	inch	90	84 – 96	90	84 – 96
Weight	lbs	885	745 – 1040	950	800 – 1110

Furthermore, the plant shall be prepared for receiving the so-called "Hesston"-bales (4' × 4' × 8') in dimensions as listed in Table 5.2. Receipt of the two bale types (New Holland and Freeman) are made in campaigns, which means that only one type of bale is received at a time. Change from one bale type to another is done on Mondays, where the storage will be at a minimum.

Table 5.2 Hesston bale dimensions.

Bale type		**Hesston**	
	Unit	**Design (nominal)**	**Variations**
Width	inch	48	46 – 50
Height	inch	51	49 – 53
Length	inch	94.5	88.5 – 96
Weight	lbs	1395	1200 – 1725

It is unavoidable that during transport when it is raining or roads are wet, the bales will be exposed to surface moisture. If the bales otherwise comply with the requirements in Table 5.3 for moisture content, surface moisture originating from the transport will not cause the switchgrass to be rejected. In designing the storage and processing equipment, the design values listed in Table 5.3 were used.

Table 5.3 Design values.

Item	**Unit**	
Type of bale		3' × 4' × 8' and 4' × 4' × 8'
Weight, min.	Lbs	745 *
Weight, nominal	Lbs	1000
Weight, max	Lbs	2000
Foreign objects in the straw (stones, metal, etc.) max.	% weight	2
Width, min. / max.	Inch	44 / 51
Height, min. / max.	Inch	32 / 53
Length, min. / max.	Inch	84 / 96
Moisture content, min.	% weight	9
Moisture content, nominal	% weight	15
Moisture content, max.	% weight	25
Moisture content in local spots, max	% weight	40

*Some years, when a poor yield results in a limited amount of switchgrass, a load may comprise a few bales of switchgrass with a minimum of 700 lbs.

Before unloading, the crane operator will make a visual inspection to determine whether manual moisture measurement of the load is necessary. If the moisture content is measured manually, it will be carried out by means of calibrated Delmhorst moisture measuring probe or equal. The reception control consists of inserting the moisture measuring probe into the areas, which by visual inspection seems to be critical, to make sure that the bales comply with the specifications. However, neither a switchgrass bale nor an entire load can be rejected due to the moisture content in the outer 2 inches of all the surfaces of the bale exceeding the requirements as stated in the above table.

To minimize the fuel delivery price, some switchgrass suppliers may therefore choose to store the bales outdoors. The upper layer of such a stack will probably not be usable for energy purposes. Even if the stack has not been covered by a tarpaulin or similar, the upper layer shall probably have to be rejected or used for other purposes. The lower layers generally have a moisture content, which does not deviate much from the moisture content at the time of harvest. However, rainwater or moisture might enter the stack during storage causing localized spots of high moisture content. Such spots or minor areas, which may have localized moisture content of 30-40%, are not to cause any stops in the process and transport equipment, which would require manual intervention or possible cleaning.

Switchgrass contains foreign bodies in the form of stones, metal and wooden objects. These impurities in the switchgrass may make up as much as 2% of the weight. Stones appear in sizes from about 4 inches in diameter and smaller. Metal objects may be in the form of screws, nuts, fencing wire, components from agricultural machines and trucks. There are examples of spears from tractors found which had a length of up to 32 inches. Wooden objects may appear in sizes ranging from half fencing posts and smaller. The mentioned foreign bodies are not to cause any damage to the transport and processing system. Foreign bodies of up to 1.5 lbs. or up to 4 inches at the longest side are to be accepted as normally occurring in switchgrass and are therefore not to cause any stop of the process or transport equipment.

5.7.2 Truck Specifications

Two types of semi-trailers will be used for transportation:

1. Semi-trailers with a body length of 53 ft. (16.15 m) and a total length of 75 ft (22.86m). At a maximum bale length of 8 ft. (2.44 m) and seven bales in a row, the bales will overhang each end with 1.5 ft (0.46 m). This complies with Iowa Highway Safety regulations and does not impair the truck's maneuverability.

2. Semi-trailers with a body length of 48 ft. (14.63 m) and a total length of 70 ft (21.34m). These semi-trailers will carry six bales in a row.

To have flexible and financially attractive transport, it will be possible for the truck driver to leave his transports at a parking lot close to the switchgrass storage. This way it will be possible for transports to arrive at all hours of the day regardless of the opening hours of the storage. During the opening hours of the storage, it will be manned with two persons: one operating the crane and one driving the spotter truck (the function of the spotter truck is defined in section 5.8.3).

It is not required that the trucks use a net during transport. When arriving to the storage facilities the bales are typically only strapped.

5.8 Site Requirements

The section will briefly describe the requirements needed for implementation of the proposed design. First, the needs for the proposed storage and processing buildings will be discussed. Next, the mechanical, electrical, plumbing, and site requirements for these two buildings will be detailed. Last, the truck loading and staging patterns will be disclosed.

5.8.1 Storage and Processing Building Requirements

Storage and processing buildings shall to be located on the small hill just west of existing boiler plant facility (approximately 1,000 feet away). As mentioned in chapter 2, this new location has been chosen to allow for the potential future expansion for OGS. One advantage of this new location is that the delivery of the switchgrass bales can be conducted outside of the security area (fenced and gated). In addition, this location also reduces the amount of OGS plant traffic originally expected relative to the location on the east side of the existing boiler building.

The storage barn shall be 50,200 square foot (4665 m^2) with an approximate 2,000 square foot (186 m^2) elevated transfer gallery to the 14,400 square foot (1,338 m^2) process building. These buildings shall be located on a previously used 20,000 square foot (1,860 m^2) parking area currently used as a storage area. The ground elevation differences from one side of this area to the other will require approximately five feet of cut and/or fill grade-work. The road leading into the switchgrass storage barn shall be concrete. The road and turn around out of the storage barn shall be concrete. The road, adjacent to, and west of the storage barn shall be concrete. The parking areas shall be compacted C-stone. This C-stone is a byproduct of the existing boiler plant facility. (See drawing 732-1003 located in Appendix 1 for detailed view of the proposed site).

5.8.2 Utilities

Plumbing and Mechanical

The existing sanitary sewer and tap-water lines, running from the existing boiler building service to an abandoned guard house located next to the gate (approaching the new facility), shall be extended to the process building (see drawing 732-8001 and 8002). These utilities (sanitary sewer and tap water) to and from Alliant Energy's plant may be metered if desired, and will be used for a single toilet, sink, and for eye wash stations. A bottled-water dispenser shall be used to supply drinking water. There will be no natural gas service available for this project. Steam heat will be used from the existing boiler (see Appendix 2 Section 5. Auxiliary Systems for further discussion).

Fire Protection

Four fire hydrants shall be installed outside of the buildings, with two fire department hose connections. The fire department hose connections will allow the fire trucks to increase the pressure of the water should a drop in pressure occur. There shall be small hose stations as well as fire extinguishers inside the new facilities.

Electrical

Facility power shall come from the main (13.8 KV) switch box service located at the southeast side of the plant. The buried facility power line currently runs to an abandoned substation and shall be reused for the new facility if possible. Two transformers will be installed and located to take advantage of this existing buried line and to deliver the required electrical services for the new facilities (see Appendix 2, Section 7. Electrical for further detail).

5.8.3 Parking, Staging and Loading

The parking and staging area surrounding the switchgrass facility is designed to accommodate two types of truck drivers. One group of drivers considered are those that will not leave their trailer in exchange for an empty trailer—these drivers will likely be farmers who own their own trailer and prefer to make deliveries themselves. The second group of drivers considered will exchange their full trailer for an empty trailer to avoid potential waiting delays at the storage barn—these will likely be contract drivers who handle deliveries for farmers who do not wish to perform their own deliveries.

Approximately 12,000 square feet (1115 m^2) of switchgrass parking shall be available for deliveries just to the west of the new storage barn and processing building (see drawings 732-1001 and 1003 in Appendix 1). This parking or staging area is to prevent potential traffic backups at the unloading facility. There shall be approximately 500 feet (6-truck capacity) of available space for trucks to queue in front of the storage barn. This area will be used by both groups of drivers discussed above. The normal unloading time per truck, including clean up, will be about 20 minutes. There are two receiving/unloading bays in the storage barn. Therefore, if there is a line of six trucks at the facility, the last driver in line will have to wait at least 60 minutes. Every effort will be made to coordinate all deliveries to minimize truck backups and resulting driver waiting time at the receiving facility.

Drivers who prefer not to exchange their trailer will proceed directly to the receiving facility upon arrival at the site. If there is a line of trucks waiting to be unloaded, either the drivers will have to wait in front of the storage barn or in the staging area until the switchgrass facility is clear. These drivers shall arrive during regular receiving hours of the processing facility and will drive their trucks into the receiving bay for delivery and unloading. These drivers can take priority over the spotter truck (discussed below) to alleviate potential space concerns in the staging area.

If there are trucks waiting to be unloaded, drivers that can exchange their full trailer with an empty trailer will drive directly into the staging area upon arriving at the site. They will drop their loaded trailer, hook onto an unloaded trailer, and leave for the next haul. A driver in a spotter truck will shuttle the loaded trailers from the staging area to the receiving facility during periods of low congestion (short lines of trucks) at the receiving facility, then park the empty trailers back in the staging area. This system will also allow delivery drivers to drop their loaded trailers before and after receiving facility operating hours—again, the driver will then pick up an empty trailer for their next haul.

This use of a staging area will reduce the wait-time of delivery drivers and will allow for off-hours deliveries to the site. When the spotter is not staging deliveries, the spotter shall be expected to provide additional clean up in the unloading area.

6. Process in General

This chapter provides an overview of the whole storage and process system design envisioned by Tech-wise. The next four chapters will provide more general design related information on the storage and reclaim system (Chapter 7), processing equipment (Chapter 8), pneumatic transport system (Chapter 9), and the burner design (Chapter 10). More detailed design information, i.e. preliminary equipment specifications, for each of these four chapters is located in Appendix 2.

For processing 25 tph switchgrass, two storage bays are to be supplied - each with one overhead bridge crane. When arriving to a storage bay, the overhead crane unloads the trucks. The crane shall take 12-14 bales - one course - per operation. Either the switchgrass bales are transferred to available space at the storage or they are transported to the switchgrass processing plant on a twin bale chain conveyor placed at the end of each of the two storage bays. These conveyors are situated in proximity to the unloading area to minimize the unloading time.

In the following process description, the processing equipment refers to the equipment used at Studstrup Power Plant. This layout of equipment is only given as an example and shall not be considered as the final design to be offered. (See drawing 732-2001 in Appendix 1 for detail).

The twin bale chain conveyor transports the bales to a transfer vehicle, which transfers the bales laterally to the processing trains. The chain conveyor placed before a de-baler controls the switchgrass feeding to the boiler. Before the switchgrass is fed into the de-baler, the twine holding the bale shall be removed. The switchgrass then falls from the conveyor – one pressing at a time – into the de-baler. The de-balers selected in this design are modified heavy-duty waste cutters. This de-baler type does not only shred the switchgrass, but it also reduces the switchgrass size to a certain extent. The pre-grinding in the de-baler is considered important for the final grinding of the switchgrass in the hammermill.

Under the de-baler, the shredded switchgrass is transported to a belt conveyor to further loosen the switchgrass and to meter the flow with the leveling rolls. The switchgrass is vacuumed from the belt conveyor through a stone trap, which removes the heaviest foreign objects. After the stone trap, the switchgrass proceeds into a hammermill where the switchgrass is milled into pieces smaller than 1 inch or 2 inches depending on the mesh size of the screen. From the hammermill, the switchgrass is fed from the screw conveyor bin through a rotary airlock to the pneumatic transport system. The transport system delivers the switchgrass to the boiler through a pipe to a burner feed system. Four milling lines feed into four parallel pipe sections.

7. Storage and Reclaim

7.1 Introduction

The switchgrass storage is a vital part of the total plant concept and the size of it can be varied individually according to the need and operational philosophy of each plant. The parameters influencing the size of the storage are (in no particular order):

- the amount of switchgrass fired per hour
- the hours available for unloading
- the operating time at a daily or weekly basis
- the security of supply
- the maximum allowable space requirement
- the plant costs
- the fire precautions
- the maximum stacking height

7.2 General Process and Equipment Description

In this section of Chapter 7, the general functionality of the storage barn and the equipment within the barn is detailed. Within this section, the Storage Management System (SMS) is used as an inventory control mechanism. The SMS is an example of the level of control the project requires. Other equivalent control systems will be considered.

7.2.1 The Storage Barn and Storage Cranes

The two storage bays within the storage barn shall be designed for a co-firing capacity of 12.5 tph each, which is 2,100 tons per week per bay. The storage barn capacity has been designed for unloading delivery trucks from 7:00 a.m. until 3:00 p.m. Monday through Friday. This means that the storage has to have at least a capacity equal to the consumption from Friday 3:00 p.m. until Monday 7:00 a.m. (64 hours of full load). The minimum capacity presumes a full storage on Friday afternoon. Incorporating a safety factor for a late start on Monday, the minimum capacity was raised to 70 hours of full load (875 tons). The delivery hours follow one clerk shift of 40 hours with 4,200 tons being delivered. Using the truck specifications for 42 bale truck deliveries (section 7.2.1), each storage crane has to be able to unload at least 2.5 trucks per hour. This translates to an average delivery rate of 24 minutes per truck including preparation and cleaning after unloading. According to time studies done at Danish straw-fired plants, two layers of 12 bales (two 12-bale courses) can be unloaded within 12 minutes. Therefore, it is assumed that three 14-bale courses of switchgrass (42 bales) can be unloaded in less than 18 minutes. *The unloading rate capability of the cranes must be faster than the average delivery rate considered which is met with this design.* For convenience of the delivery drivers and allowing an extra margin of error for delivery scheduling, weather-related delays, etc., the delivery hours at the facility may be extended to more than 40 hours.

The cranes are to be operated automatically (unmanned) during non-delivery hours. When the processing DCS system asks for delivery of bales, one of the cranes is to drive to the position of the bales to be picked up as specified by the SMS. The cranes deliver the bales to the chain conveyor, transporting the bales side by side to the transfer vehicle. The transfer vehicle receives two bales at a time and transfers one bale at a time to the processing trains.

7.2.2 *Switchgrass Moisture and Weight Measurement System*

Each crane must be equipped with a weight measurement system for receiving switchgrass. The measurement system must be approved for accounting purposes. Moisture measurements are to be made on all deliveries. The measurements of moisture content and weight must be displayed for the crane operators.

Each of the seven tongs of the crane lifts up two bales. The moisture of each pair of bales is to be measured at three positions to obtain a representative measurement of the average moisture of the bale. The crane supplier will perform guarantee measurements to demonstrate the system accuracy. These guarantee measurements are made by drilling samples from measured bales. The samples are weighed before and after drying in a cabinet drier, and the moisture content of the samples is calculated.

7.2.3 Switchgrass Storage Management System (SMS)

Measuring and registration of the switchgrass supplied must be as automated as possible to minimize the unloading time and labor costs. When driving into the storage barn, the traffic is controlled by means of traffic lights outside and inside the storage barn; the lights direct trucks into the storage bays. Then, an overhead bridge crane unloads the trucks with the assistance of a crane operator (see drawing 732-7005 in Appendix 1 for an illustration of the truck unloading process). The crane shall take 12-14 bales - one course - per pick. During the unloading, the bales shall be weighed and the moisture content measured. The inventory control system or Storage Management System (SMS) communicates both with the cranes and with the incoming truck drivers. The truck drivers communicate with the SMS via card readers placed so that the truck drivers can reach them from the cab of their trucks. The truck and bale data (bale weight and bale moisture content level) shall be stored in the SMS and used to generate payments to the appropriate fuel suppliers and to create a statistical log of plant operations.

The SMS makes it possible to store both 12 and 14 bale courses in the same storage bay. The 12 bale courses will be placed in the storage bay close to the unloading area and the 14 bale courses in the opposite end. When reclaiming from the storage, the SMS system will reclaim the 12 bale courses first and in accordance with “first-in, first-out” principle (FIFO). During delivery hours, the SMS directs the crane to deliver the unloaded bales from the trucks either to an available space in the storage barn or to the twin bale chain conveyor. The twin bale chain conveyor is placed at the end of both storage bays, which is at the start of the processing train.

The SMS will be comprised of several computers, which can exchange data via a local network. Figure 7.1 below schematically shows how the information will be exchanged on the SMS network.

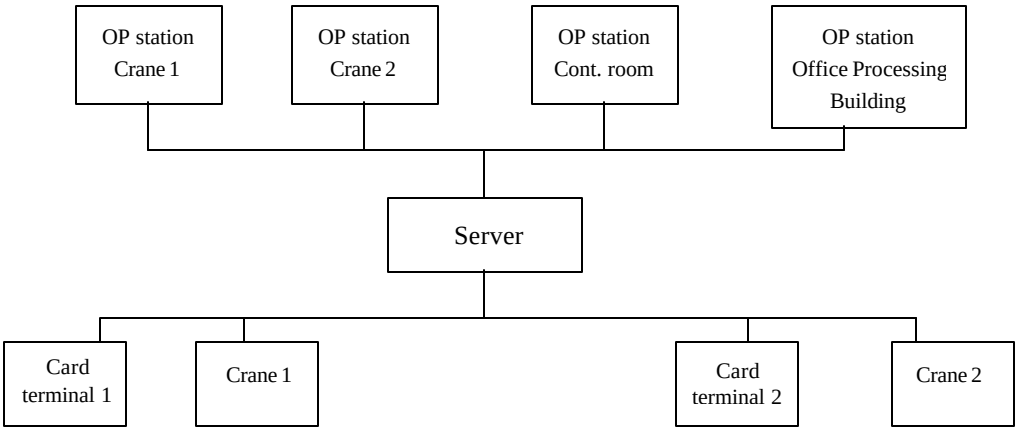


Figure 7.1 SMS network

7.2.3.1 The Functions of the System

The two main functions of the SMS are to manage the storage input and output and to control the cranes in storing and reclaiming switchgrass bales (consulting to the crane management). If, for instance, the SMS proposes a particular position in the storage barn, it must be possible for the crane operator to place the switchgrass at another position in the storage barn, while the SMS registers this other position. Furthermore, it should be possible to take switchgrass out of the storage for the purposes of combustion or return to the truck unloading area. The other functions of the SMS are to:

1. Send information on supplied switchgrass to the accounting system.

2. Receive information from card readers regarding the identification of supplier and carrier.

3. Send information to the card reader/printer regarding receipt for supplied switchgrass.

4. Receive or send information to or from the crane programmable logic controller (PLC) concerning switchgrass data and administration of switchgrass storage.

5. Present, handle and file information regarding storage data.

6. Interface with the user operating and keying parameters related to the day-to-day operation of the SMS.

7.2.3.2 The Server, Switchgrass Processing Building

The process computer in the switchgrass processing building is the central part of the system and is connected to the process by means of the crane control's PLC for crane 1 and 2 as well as the two card readers. The communication with these units takes place via a standard interface. The server will be placed in the electrical room within the switchgrass processing building. The function of the server will be exchanging information with the two crane systems in the bay.

On demand from the two PLCs, the SMS will send or receive information on the switchgrass received or reclaimed at the storage. The main information, which the SMS will receive from a PLC, is the moisture content and weight of the switchgrass bales. The main information, which the SMS will send to the PLC, is the position of the switchgrass to be stored or reclaimed at the storage.

The switchgrass is to be stored in 12 or 14 bale courses, depending on the load of the trucks delivering the bales. It is to be assumed, though, that most of the bales will be delivered in 14-bale courses. The process of reclaiming from the storage barn shall take those bales stored in 12-bale courses first, then use FIFO methodology.

The card readers are an integrated part of the SMS and are used for identification of the switchgrass supplier when delivering the switchgrass. The received information is handled and registered by the SMS. One of the handling procedures to take place is to approve the moisture content and the weight of the received switchgrass and to calculate the positions of where to load and unload switchgrass in the storage. The information to be registered is among others the location of the switchgrass in the storage together with data on moisture, weight and supplier.

7.2.3.3 Operator Station, Office at the Switchgrass Storage

An operator station is placed in the office of the switchgrass storage, where monitoring of the bay takes place. One operator station must be located in the power station control room and one operator station by each crane operator. The computer in the office at the switchgrass storage barn will inform the entire system. The information, to be presented, will be collected from the server via a network and will be presented by means of screen pictures and reports. Entering and changing of parameters for switchgrass and switchgrass storage, e.g. limit values for moisture, correction of stocks, will be done through this computer.

7.2.3.4 Information on Crane Operation

The storage crane shall have three operation modes: automatic, semi-automatic and manual. Outside delivery hours, the crane is typically in automatic operation mode, and

the switchgrass bales are transferred to the processing plant. The SMS will register all incidents. During automatic operation mode, people are not allowed to stay in areas where the crane operates. These areas will be closed off by railings, and entrance doors will be equipped with switches stopping the cranes if the doors are opened. During delivery hours, semi-automatic operation mode is typically used, and the SMS approves the information scanned or typed into the card reader. Manual operation mode shall be applicable during delivery and non-delivery hours. While in manual or semi-automatic operation, the crane shall ask where to place the switchgrass and then place it at the given position. However sometimes in the semi-automatic mode, the crane shall take the bales directly to the processing plant, and this is also to be registered in the storage management system.

8. Processing Equipment

8.1 Introduction

A general issue to discuss when designing the overall co-firing system is the requested availability. This is of great importance considering, e.g. the economic aspects related to the maintenance of the specific co-firing plant. The number of trains (process lines) in the switchgrass processing plant has a direct influence on the availability. Splitting the processing of the switchgrass in multiple trains makes the system less sensitive to failure in feeding the boiler if problems occur in one of the trains. Looking at the investment costs though, the plant will be more expensive introducing multiple trains. Therefore, the split point going from one train to multiple trains in the processing system should be considered and optimized.

In the following descriptions, the choice of processing is based on the experience at Studstrup Power Plant, Denmark. The number of burners determines the number of processing trains. The advantage of the system is that the dividing of the switchgrass takes place before the switchgrass is processed. The disadvantage of this design philosophy is that the aggregate cost of the multi-train processing equipment is higher than it would have been if the equipment were not split into multiple trains.

One of the possibilities to obtain the requested size reduction of the switchgrass is to use a hammermill. However, apparently the hammermill suppliers do not make a hammermill in a size which would be able to process 12.5 tph. Furthermore, the first test campaign demonstrated problems distributing the pre-ground switchgrass evenly between the two burners with the system used for the first cofiring campaign. Therefore, the starting point has been to use one processing train per burner.

8.2 General Process and Equipment Description

The general process and equipment description below is an example and shall not be considered as the final design to be offered due to year 2002 testing and study work.

From the transfer vehicle the bales are transferred one by one to the processing trains. Each process line or train consists of two chain conveyors where the bales are transported at a velocity equal to the mass flow to the burner. Before the switchgrass enters the de-baler, the twine holding the bale together is cut and removed automatically. From the conveyor, the pressing layers of the bale are falling into the de-baler. The de-baler is a modified electro-hydraulic, heavy-duty waste disposal machinery with two horizontal shafts with rotating knives. These shafts are mounted on transverse beams equipped with stationary knives to obtain an actual cutting effect when the shafts are rotating. After the de-baler, the switchgrass flow is leveled on a belt conveyor.

By means of an induced draft fan with a baghouse, the switchgrass is then vacuumed through a stone trap - removing the heaviest foreign particles - into the hammermill. In the hammermill, the switchgrass is ground through a screen size of 2 inches or less. The hammermill consists of a number of fast rotating beaters, dividing the switchgrass into fine particles. The particles are caught in a hopper below the hammermill and transported by a screw conveyor to a rotary airlock. The rotary airlock transports the switchgrass into the pneumatic transport system, which transports the switchgrass to the burner of the boiler.

9. Pneumatic Transport System

9.1 Introduction

The processing building is situated approximately 1,000 feet from the boiler building. The transport of the ground switchgrass shall be done pneumatically. Pneumatic transport of ground straw on long distances has been proven successfully at Studstrup Power Plant. The Studstrup plant transports the straw via a pneumatic line approximately 1,500 feet.

9.2 General Process and Equipment Description

The ground switchgrass is transported by means of rotary airlock into the pneumatic transport system, which transports the switchgrass to the burner of the boiler. The rotary airlock prevents the transport air from entering the grinding equipment, which is to be operated at vacuum. Rotary piston blowers deliver the transport air.

10. Switchgrass Burner

10.1 Introduction

The OGS boiler is a twin fireball, tangentially fired boiler with no dividing wall. The fireballs are identified as the east and the west fireballs. The current switchgrass nozzles are located in the east fireball in the northwest and southeast corners of the boiler. These switchgrass nozzles are located between the third and fourth rows of coal

burners from the bottom. The existing burner size and location used for the first co-firing campaign were successful.

10.2 General Process and Equipment Description

The switchgrass shall be injected at even rates through four switchgrass burner nozzles. The existing two burners will be remain in the same position used during the first co-firing campaign. The two new burners shall be positioned in the northeast and southwest corners of the west fireball. These new burners will be placed between the third and fourth rows of coal burners from the bottom.

Reference

1. Amos, Wade A. (2002), *Summary of Chariton Valley Switchgrass Co-Fire Testing at the Ottumwa Generating Station in Chillicothe, Iowa*, NREL/TP-510-32424, Golden, CO, National Renewable Energy Laboratory.

Appendix 1
Preliminary Design Drawings

Table of Contents for Appendix 1

SITE PLAN
FOR CHARITON VALLEY BIOMASS PROJECT FOR THE PROPOSED AUTOMATED 25 TPH SWITCHGRASS FEED ADDITION TO ALLIANT ENERGY SITE

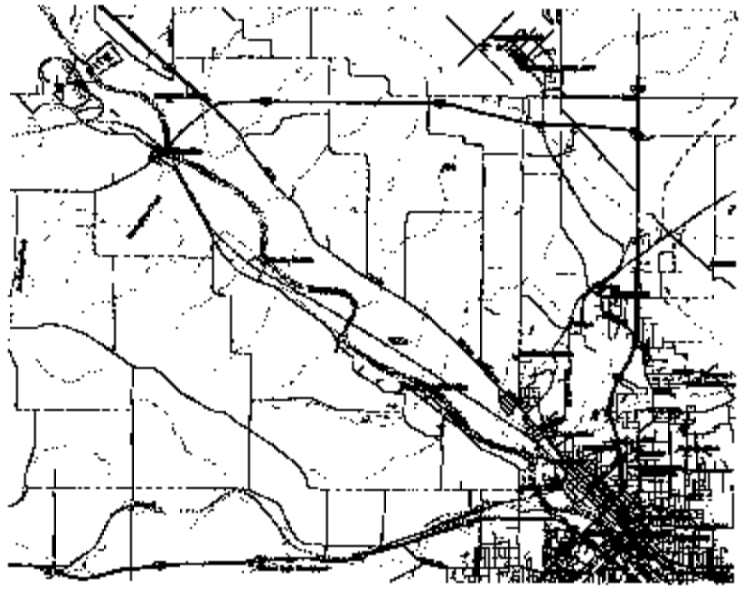
SITE ADDRESS: 20991 POWER PLANT ROAD
CHILLICOTHE, IOWA 52548

CONSTRUCTION TYPE: II-N

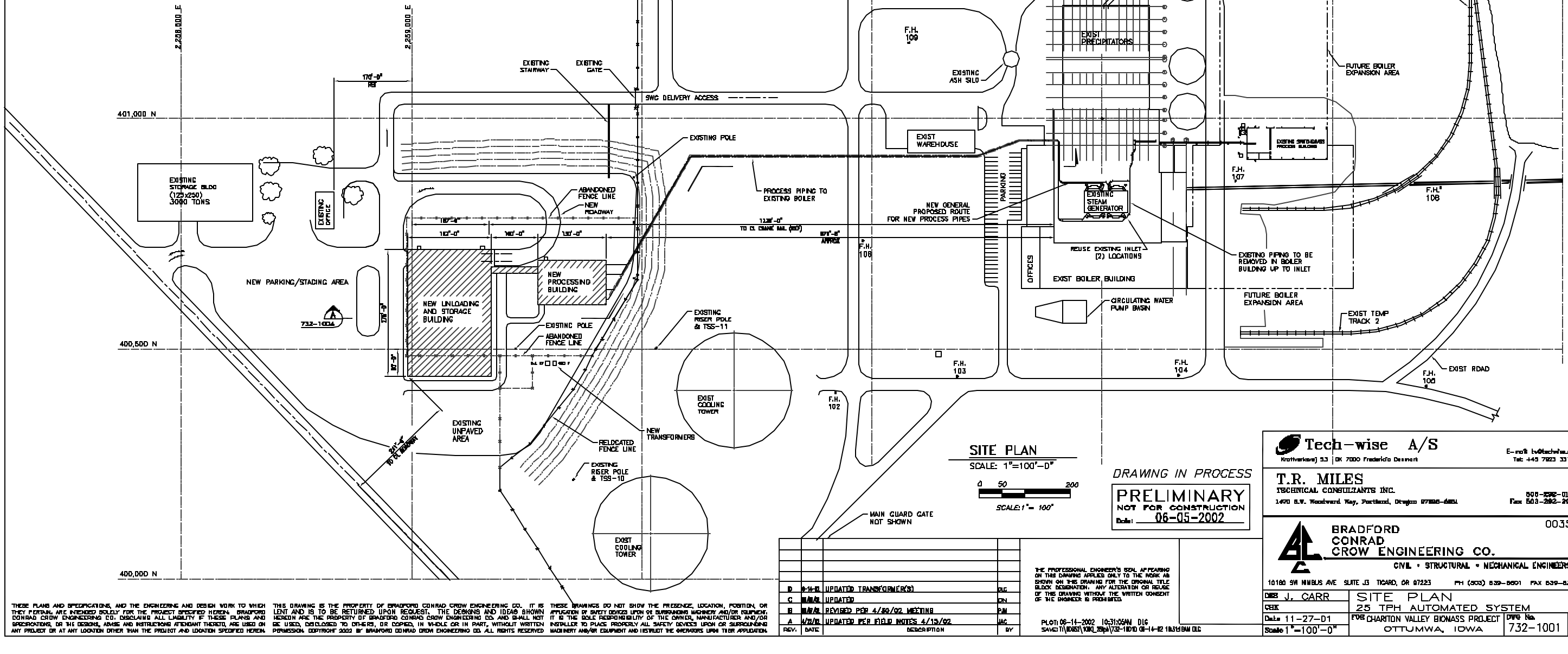
OCCUPANCY: H-3, SWITCH GRASS STORAGE/ PROCESSING FOR POWER GENERATION

FLOOR AREAS: EXISTING PROCESSING BUILDING 14,400 SF
NEW SWITCHGRASS BARN APPROX 80,000 SF
GALLERY 2000 SF

LAND USE CLASSIFICATION: I-2 (HEAVY INDUSTRIAL)



VICINITY MAP



SITE PLAN
SCALE: 1"=100'-0"

0 50 200
SCALE: 1" = 100'

DRAWING IN PROCESS

PRELIMINARY
NOT FOR CONSTRUCTION
Date: 06-05-2002

REV.	DATE	DESCRIPTION	BY
D	9-16-02	UPDATED TRANSFORMER(S)	DJC
C	8/8/02	UPDATED	DN
B	6/6/02	REVISED PER 4/30/02 MEETING	PJM
A	4/17/02	UPDATED PER FIELD NOTES 4/15/02	MJC

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PLOT: 06-14-2002 10:31:05AM DJC
SAVED: I:\DWGS\1001_25tpa\732-1001D 06-14-02 10:31:04AM DJC

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00352
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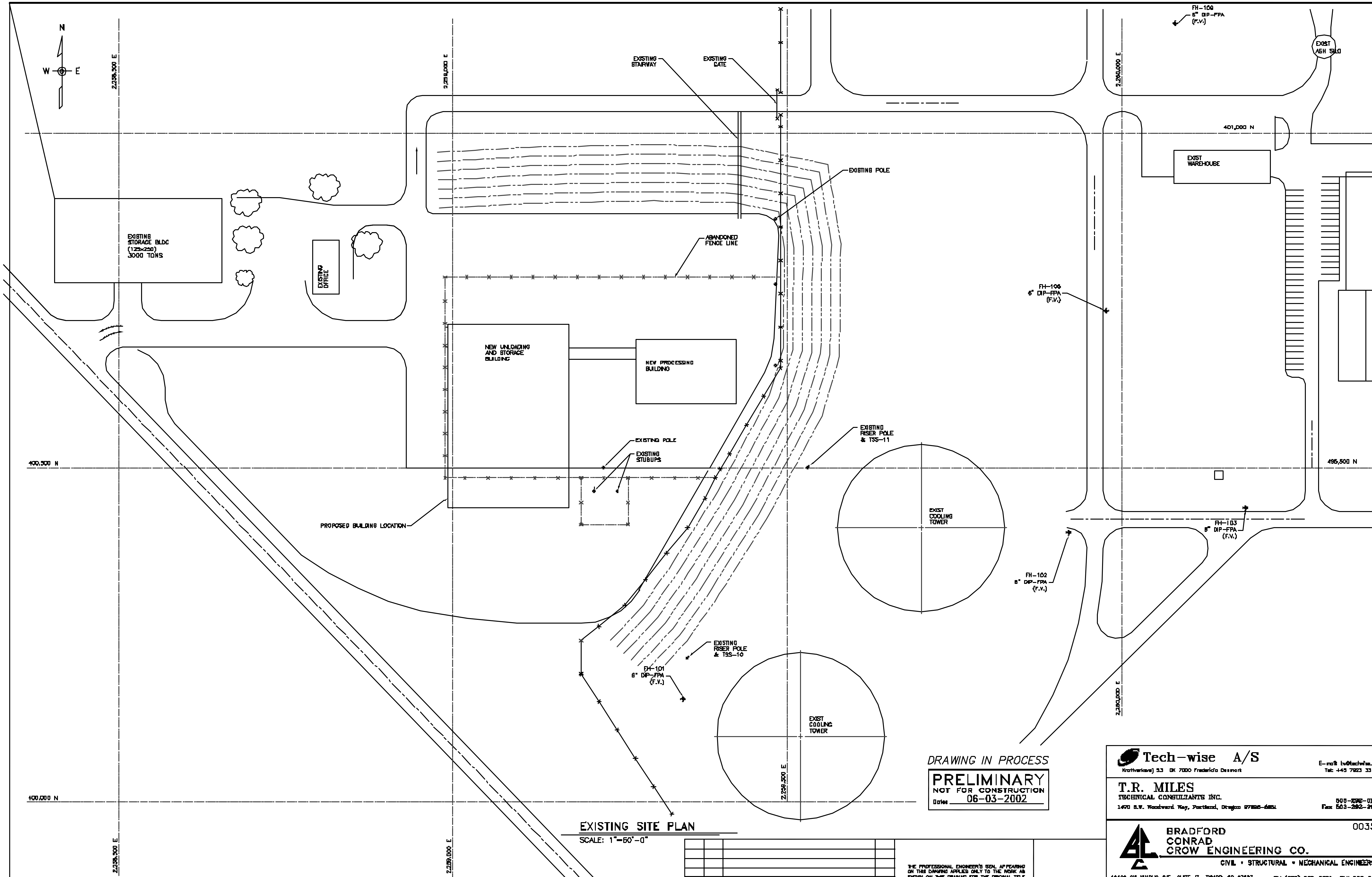
10180 SW NIMBUS AVE SUITE J3 TIGARD, OR 97223 PH (503) 639-8601 FAX 639-8251

DES J. CARR	SITE PLAN 25 TPH AUTOMATED SYSTEM		
CHK			
Date 11-27-01	FOR CHARITON VALLEY BIOMASS PROJECT OTTUMWA, IOWA	DWG No. 732-1001	REV D
Scale 1"=100'-0"			



EXISTING SITE PLAN

SCALE: 1"=60'-0"

DRAWING IN PROCESS

PRELIMINARY
NOT FOR CONSTRUCTION
Date: 06-03-2002

REV.	DATE	DESCRIPTION	BY
A	4/13/02	UPDATED PER FIELD NOTES 4/13/02	JAC

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00352

DES J. CARR	EXISTING SITE PLAN			
CHK				
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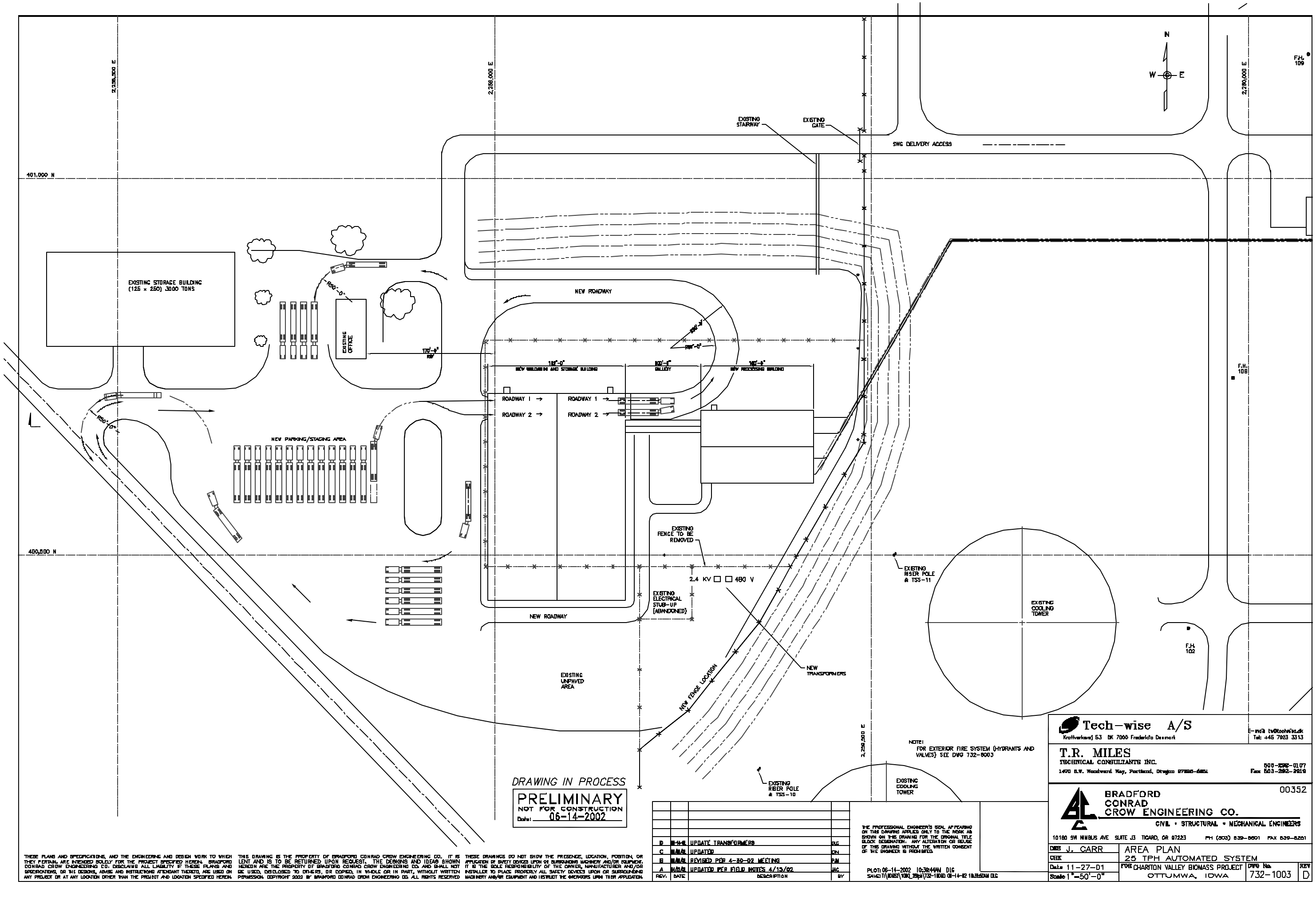
Scale 1"=60'-0"				



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NOT FOR CONSTRUCTION
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B	04-26-02	REVISED PER 4-22-02 MEETING	DLC
A	04-22-02	UPDATED PER FIELD NOTES 4/15/02	JAC

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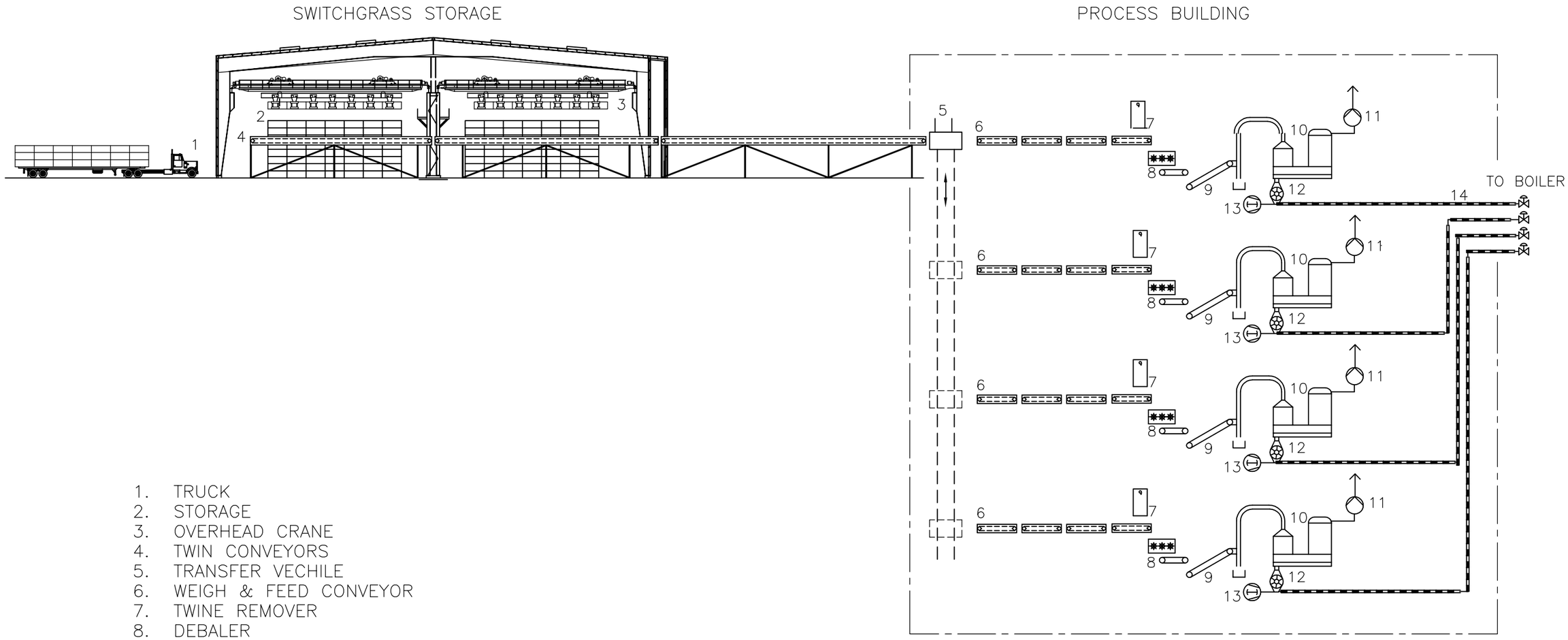
00352

DES J. CARR	AREA PLAN
CHK	25 TPH AUTOMATED SYSTEM
Date 11-27-01	FOR CHARITON VALLEY BIOMASS PROJECT
Scale 1"=50'-0"	OTTUMWA, IOWA

DWG No. 732-1003 REV D



1. TRUCK
2. STORAGE
3. OVERHEAD CRANE
4. TWIN CONVEYORS
5. TRANSFER VECHILE
6. WEIGH & FEED CONVEYOR
7. TWINE REMOVER
8. DEBALER
9. BELT CONVEYOR WITH FLOW STRAIGHTENERS
10. HAMMERMILL UNIT WITH BAGHOUSE FILTER
11. ID–FAN
12. ROTARY AIR LOCK
13. ROTARY PISTON BLOWER
14. PNEUMATIC TRANSPORT PIPELINE

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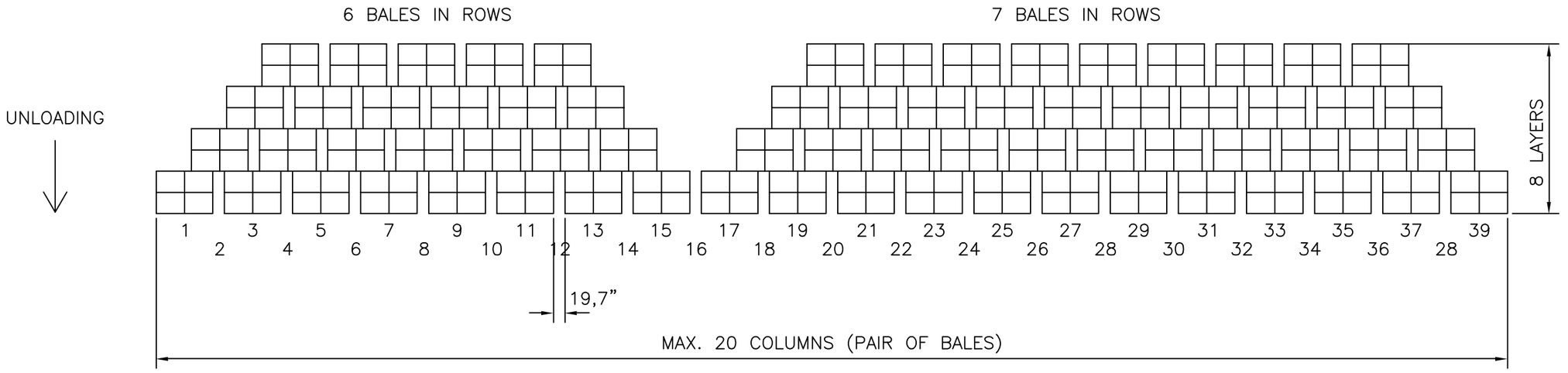
DES KT	CHARITON VALLEY MAIN PROCESS DIAGRAM		
CHK NIK			
Date 14–06–02	FOR	DWG No. 732–2001	REV a
Scale %			



MAX. 2072 BALES PER BAY
(7 BALES IN ROWS).

MIN. 1776 BALES PER BAY
(6 BALES IN ROWS).

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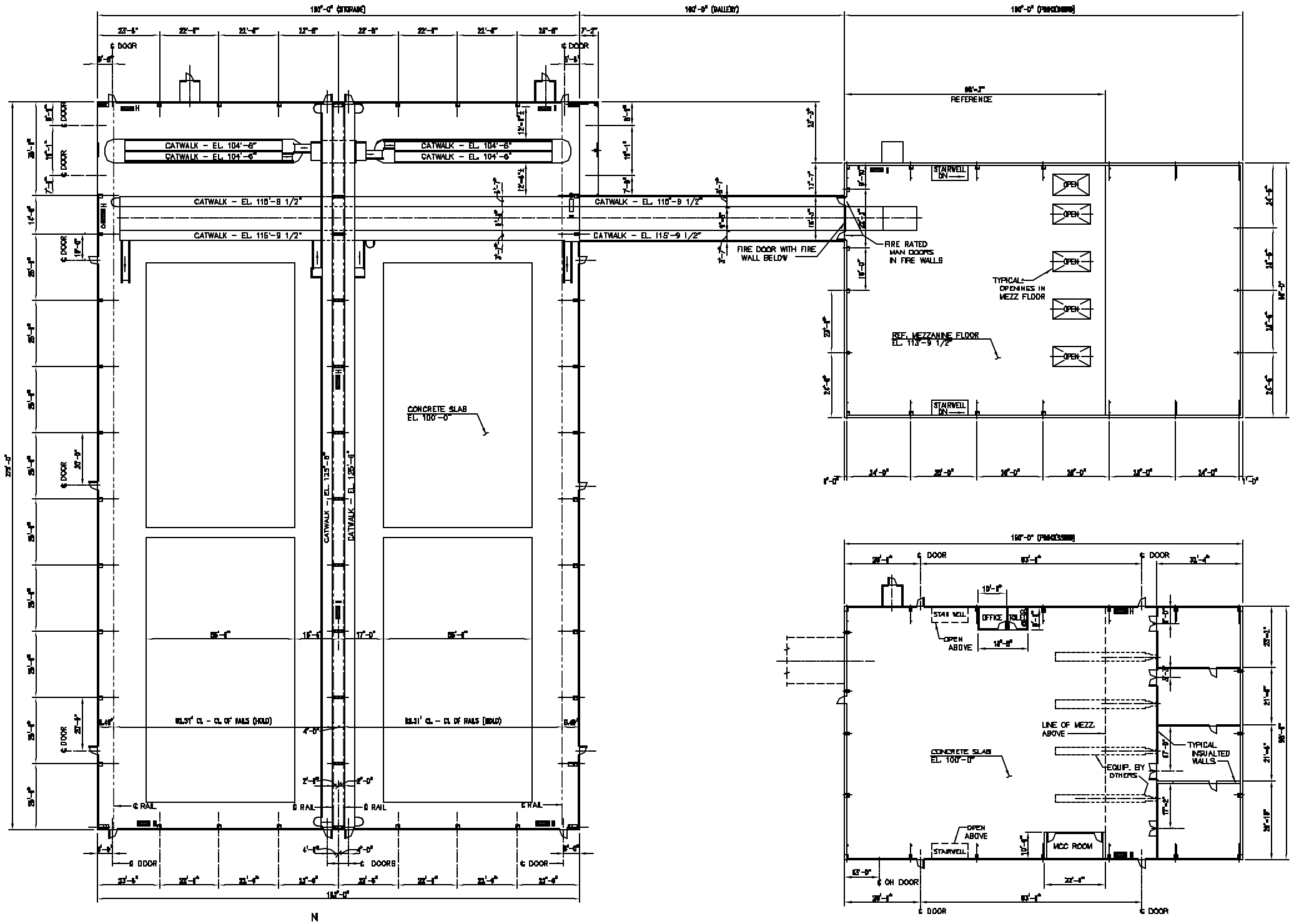
DES KT	CHARITON VALLEY	
CHK NIK	PRINCIPLE OF SWITCHGRASS STORING	
Date 14–06–02	FOR	DWG No. 732–2002 / REV a
Scale %		



BUILDING PLANS
SCALE: 1"=20'-0"

LOWER FLOOR @ PROCESS BUILDING
SCALE: 1"=20'-0"

DRAWING IN PROCESS

PRELIMINARY
NOT FOR CONSTRUCTION
Date: 06-05-2002

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00352

DES RLU	BUILDING PLANS
CHK	25 TPH AUTOMATED SYSTEM
Date 05-29-02	FOR CHARITON VALLEY BIOMASS PROJECT
Scale 1"=20'-0"	OTTUMWA, IOWA
DWG No. 732-3001	REV A

REV.	DATE	DESCRIPTION	BY
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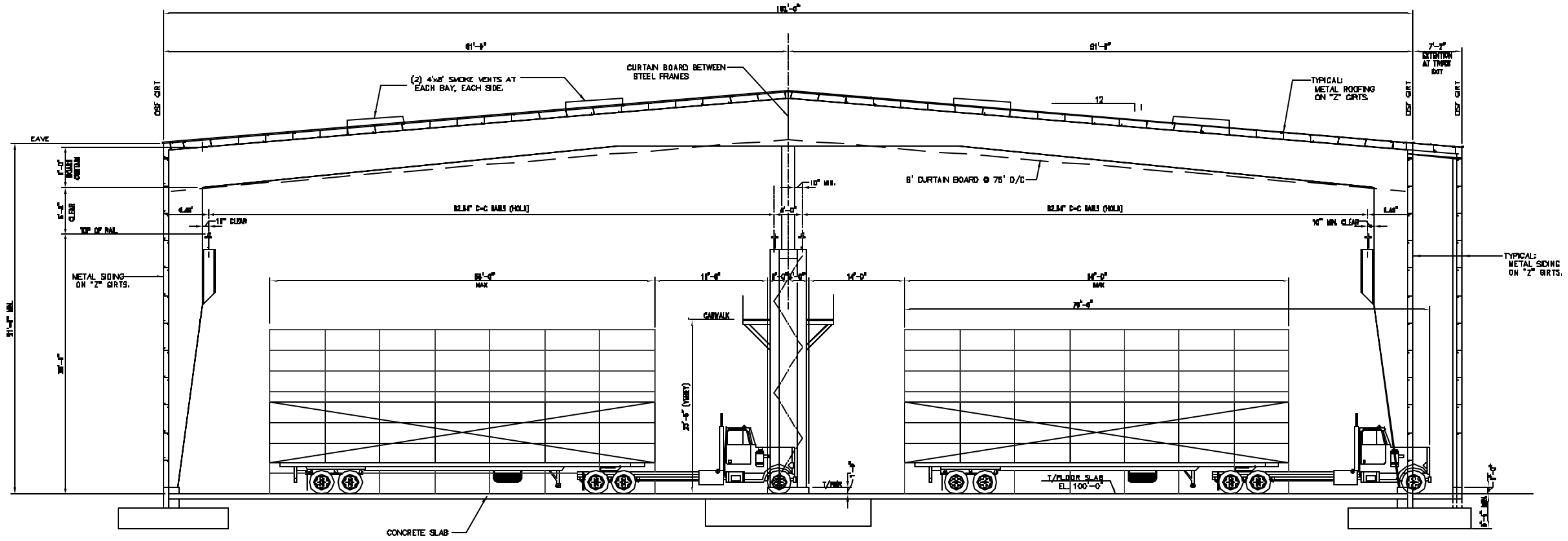

SECTION THROUGH STORAGE

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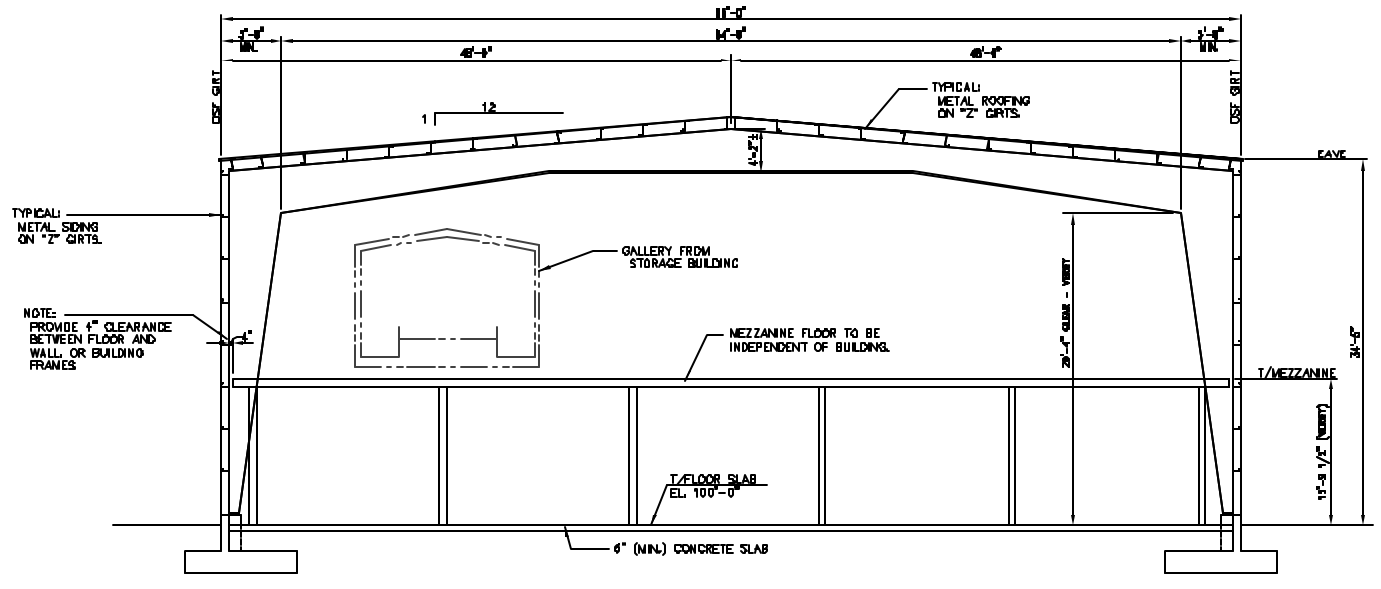

SECTION THROUGH PROCESS BUILDING

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DRAWING IN PROCESS

PRELIMINARY
NOT FOR CONSTRUCTION
Date: 06-05-2002

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REV.	DATE	DESCRIPTION	BY
A	06-05-02	UPDATED DRAWING	RLU

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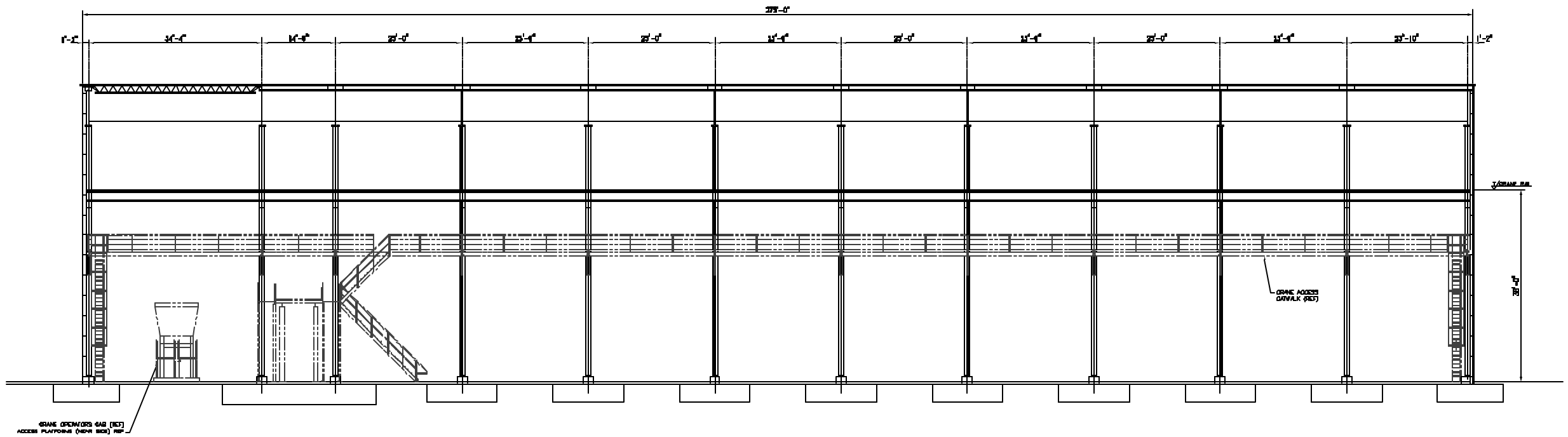
DES	RLU
CHK	
Date	05-28-02
Scale	1/8"=1'-0"

BUILDING SECTIONS
25 TPH AUTOMATED SYSTEM
FOR CHARITON VALLEY BIOMASS PROJECT
OTTUMWA, IOWA

DWG No. 732-3002 REV A



LONGIT. SECTION OF STORAGE BLDG

SCALE: 1/8"=1'-0"

DRAWING IN PROCESS

PRELIMINARY
NOT FOR CONSTRUCTION
Date: 06-05-2002

REV.	DATE	DESCRIPTION	BY

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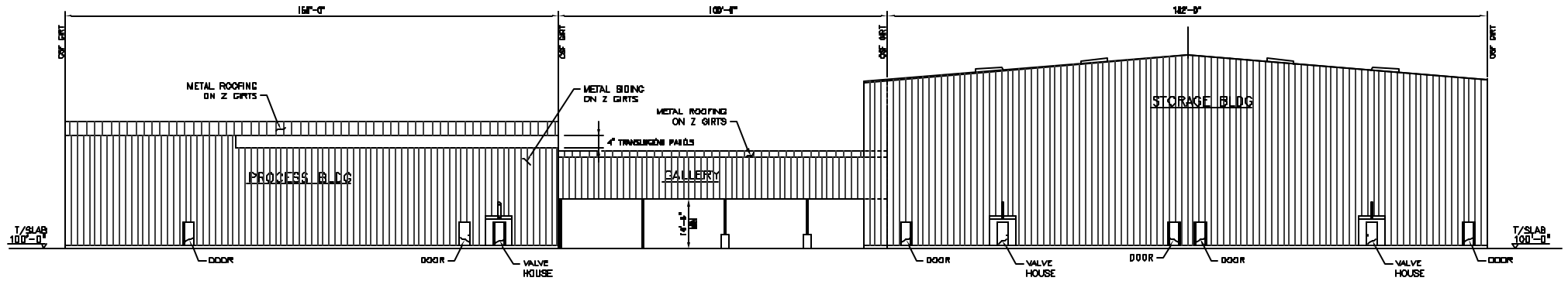
DES RLU	BUILDING SECTION
CHK	25 TPH AUTOMATED SYSTEM
Date 05-05-02	PROJ. CHARITON VALLEY BIOMASS PROJECT, OTTUMWA, IOWA
Scale 1/8"=1'-0"	DWG No. 732-3003 REV



NORTH ELEVATION (LOOKING SOUTH)

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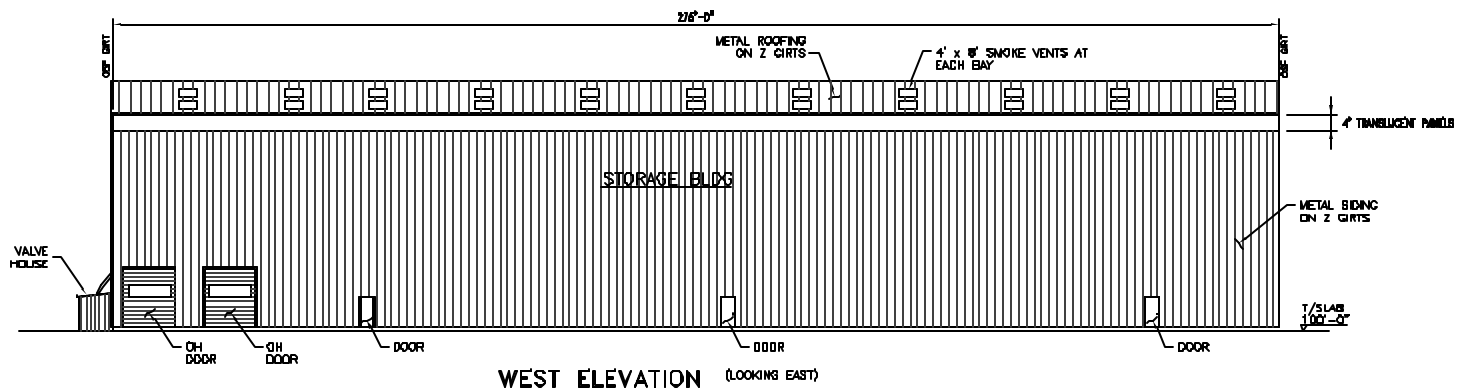

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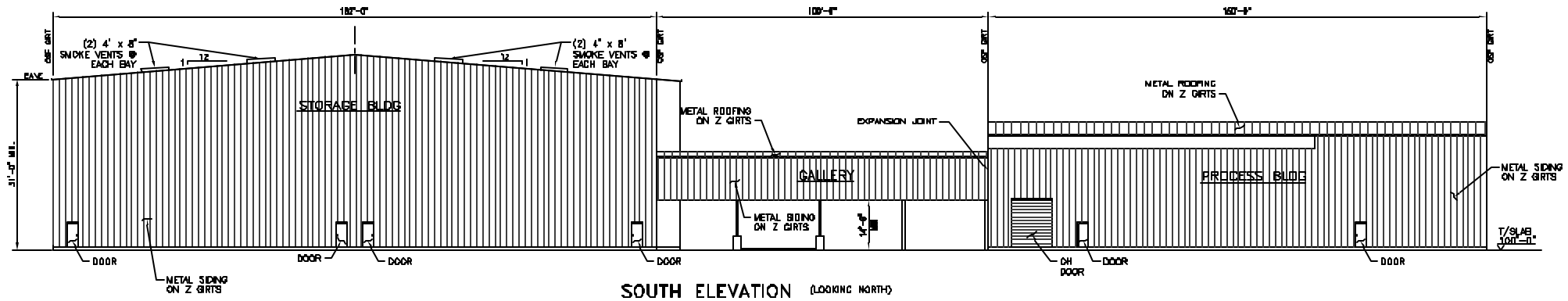

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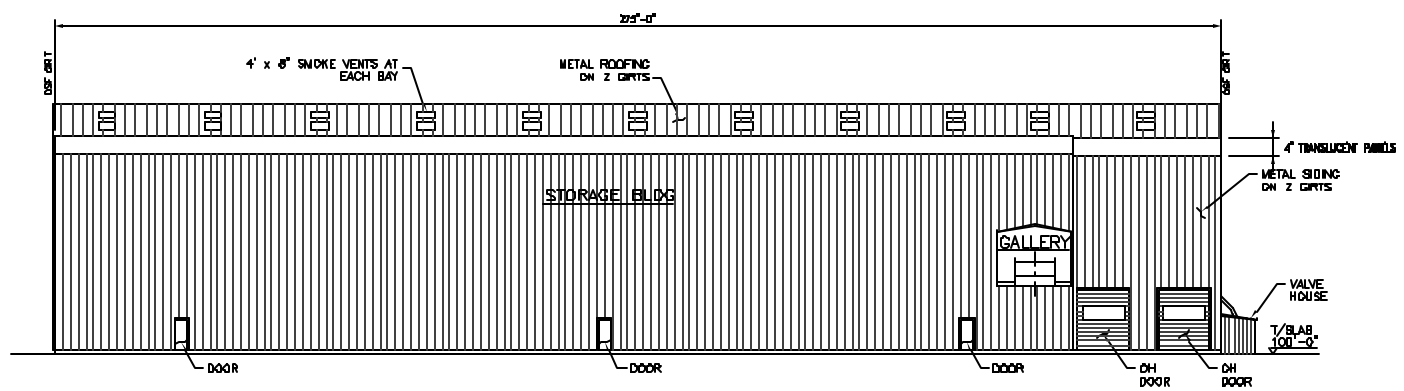

EAST ELEVATION STORAGE BLDG (LOOKING WEST)

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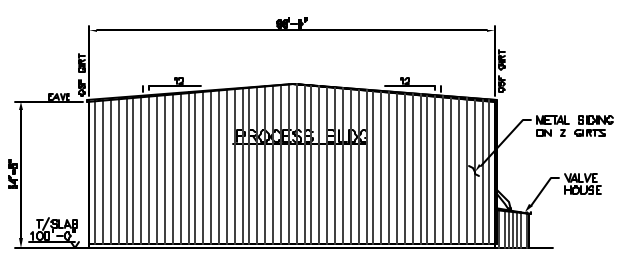

EAST ELEVATION PROCESS BLDG (LOOKING WEST)

SCALE: 1"=20'-0"

DRAWING IN PROCESS

PRELIMINARY
NOT FOR CONSTRUCTION
Date: 06-05-2002

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DES	KW
CHK	
Date	06-05-02
Scale	1"=20'-0"

BUILDING ELEVATIONS
25 TPH AUTOMATED SYSTEM
FOR CHARITON VALLEY BIOMASS PROJECT
OTTUMWA, IOWA
DWG No. 732-3004
REV

REV.	DATE	DESCRIPTION	BY

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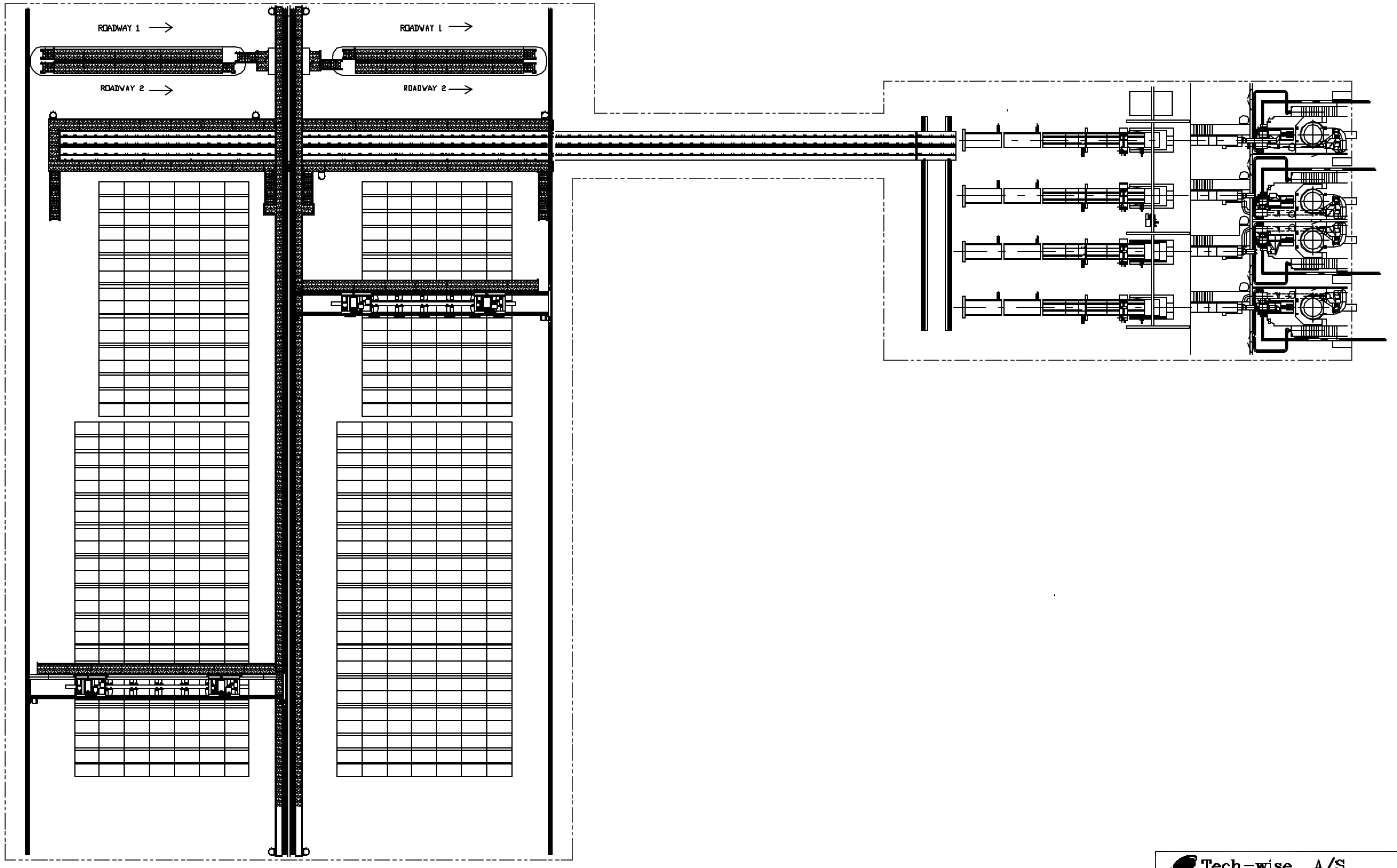

DRAWING IN PROCESS

PRELIMINARY
NOT FOR CONSTRUCTION
Date: 06-05-2002

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OD352

DES	T/W
CHK	
Date	11-27-01
Scale	1/16"=1'-0"

MACHINERY PLAN
25 TPH AUTOMATED SYSTEM
POR CHARITON VALLEY BIOMASS PROJECT
OTTUMWA, IOWA
DWG No. 732-7001
REV

REV.	DATE	DESCRIPTION	BY

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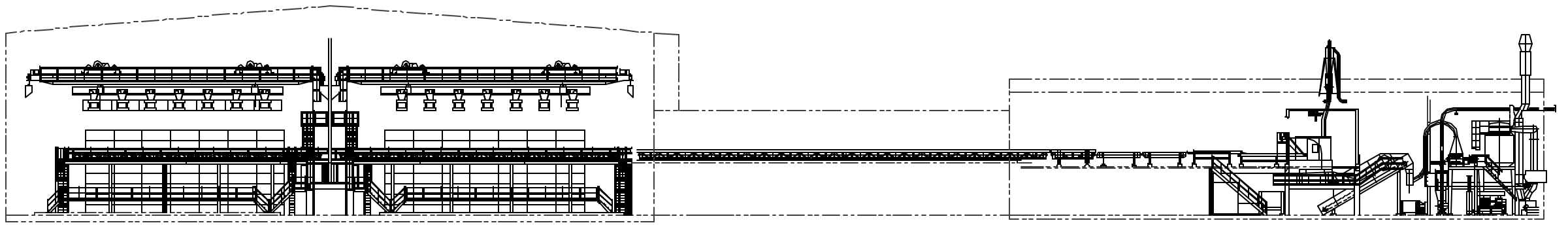

DRAWING IN PROCESS

PRELIMINARY
NOT FOR CONSTRUCTION
Date: 06-05-2002

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OD352

BRADFORD
CONRAD
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CIVIL • STRUCTURAL • MECHANICAL ENGINEERS
10180 SW NIMBUS AVE SUITE J3 TIGARD, OR 97223 PH (503) 639-6801 FAX 639-6251

DES	T/W	MACHINERY - SECTION VIEW		
CHK		25 TPH AUTOMATED SYSTEM		
Date	11-27-01	FOR CHARITON VALLEY BIOMASS PROJECT	DWG No.	REV
Scale	1/16"=1'-0"	OTTUMWA, IOWA	732-7002	

REV.	DATE	DESCRIPTION	BY

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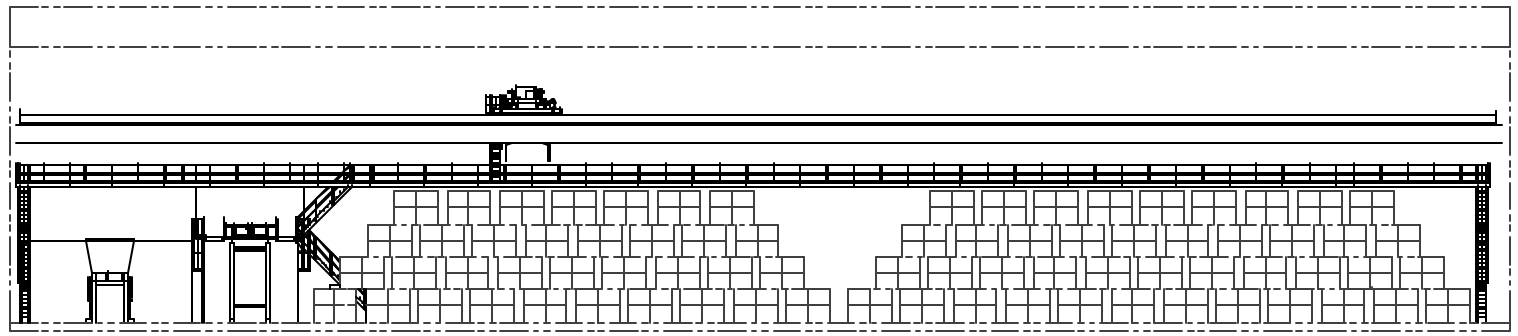

DRAWING IN PROCESS

PRELIMINARY
NOT FOR CONSTRUCTION
Date: 06-05-2002

Tech-wise A/S
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E-mail tw@techwise.dk
Tel +45 7623 3313

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DES	T/W	MACHINERY - SECTION VIEW		
CHK		25 TPH AUTOMATED SYSTEM		
Date	11-27-01	FOR CHARLTON VALLEY BIOMASS PROJECT	DWG No.	REV
Scale	1/16"=1'-0"	OTTUMWA, IOWA	732-7003	

REV.	DATE	DESCRIPTION	BY

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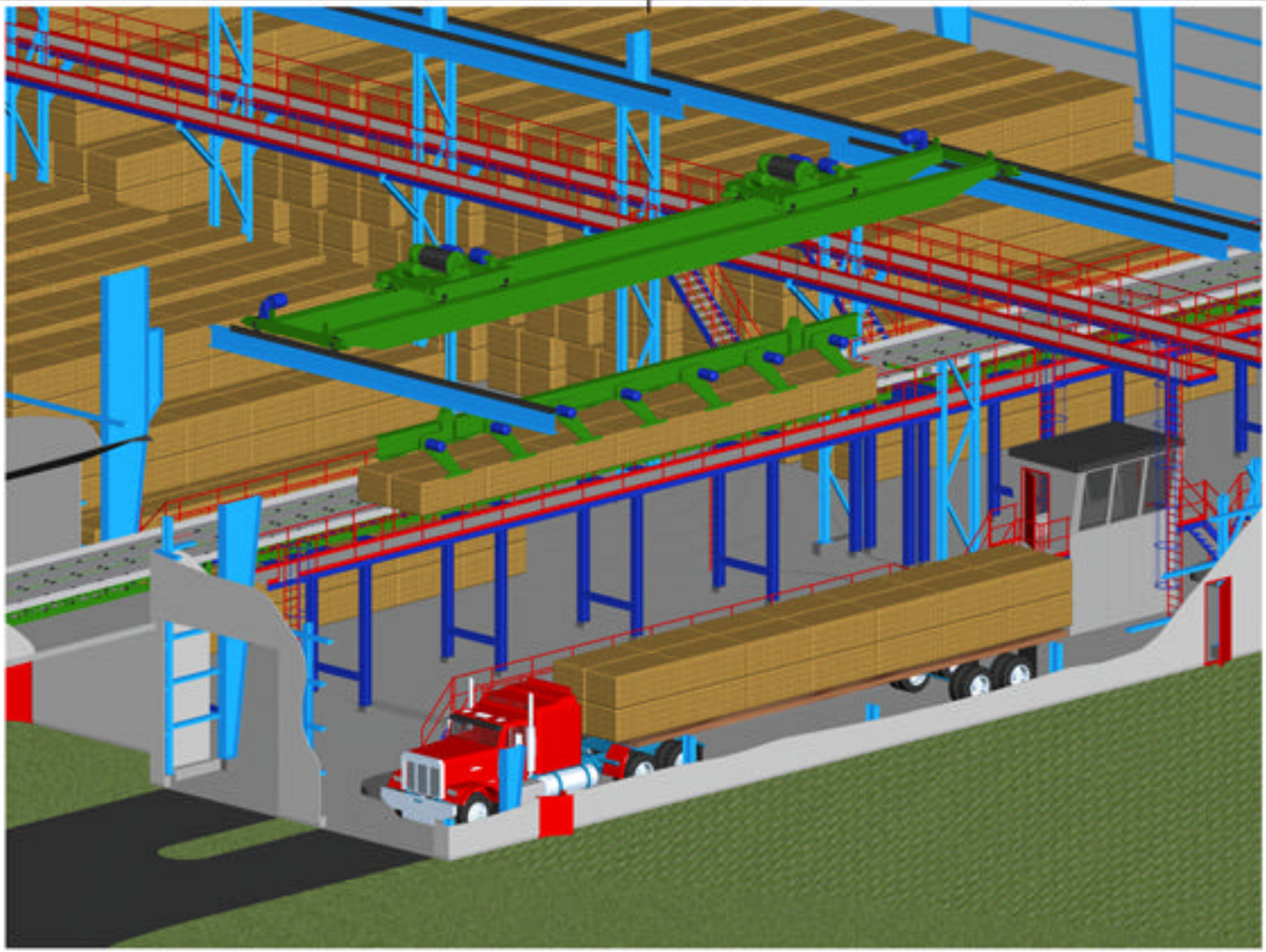
CHARITON VALLEY
SWITCHGRASS STORAGE - ISOMETRIC VIEW

17-06-02

732-7005



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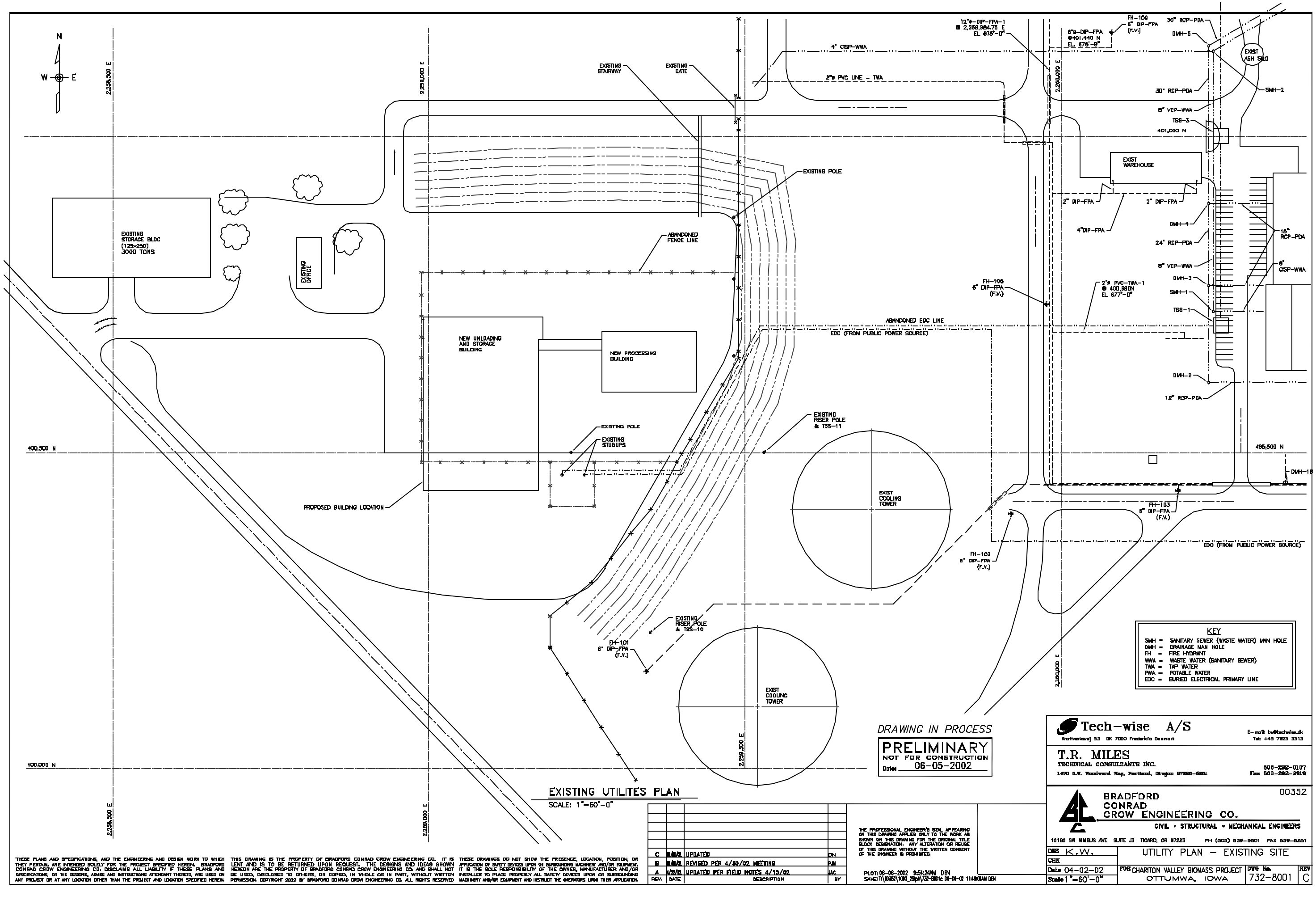
DES KT	CHARITON VALLEY
CHK NIK	SWITCHGRASS UNLOADING - ISOMETRIC VIEW
Date 17-06-02	DWG No. 732-7006



EXISTING UTILITES PLAN

SCALE: 1"=60'-0"

KEY

SWH =	SANITARY SEWER (WASTE WATER) MAN HOLE
DMH =	DRAINAGE MAN HOLE
FH =	FIRE HYDRANT
WWA =	WASTE WATER (SANITARY SEWER)
TWA =	TAP WATER
PWA =	POTABLE WATER
EDC =	BURIED ELECTRICAL PRIMARY LINE

DRAWING IN PROCESS

PRELIMINARY
NOT FOR CONSTRUCTION
Date 06-05-2002

REV.	DATE	DESCRIPTION	BY
C	6/6/02	UPDATED	DN
B	5/6/02	REVISED PER 4/30/02 MEETING	PM
A	4/2/02	UPDATED PER FIELD NOTES 4/15/02	MC

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PLOT: 06-06-2002 9:54:24AM DN
SAVED: T:\JOBS\3080_259A\732-8001C 06-06-02 11:48:08AM DEN

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00352
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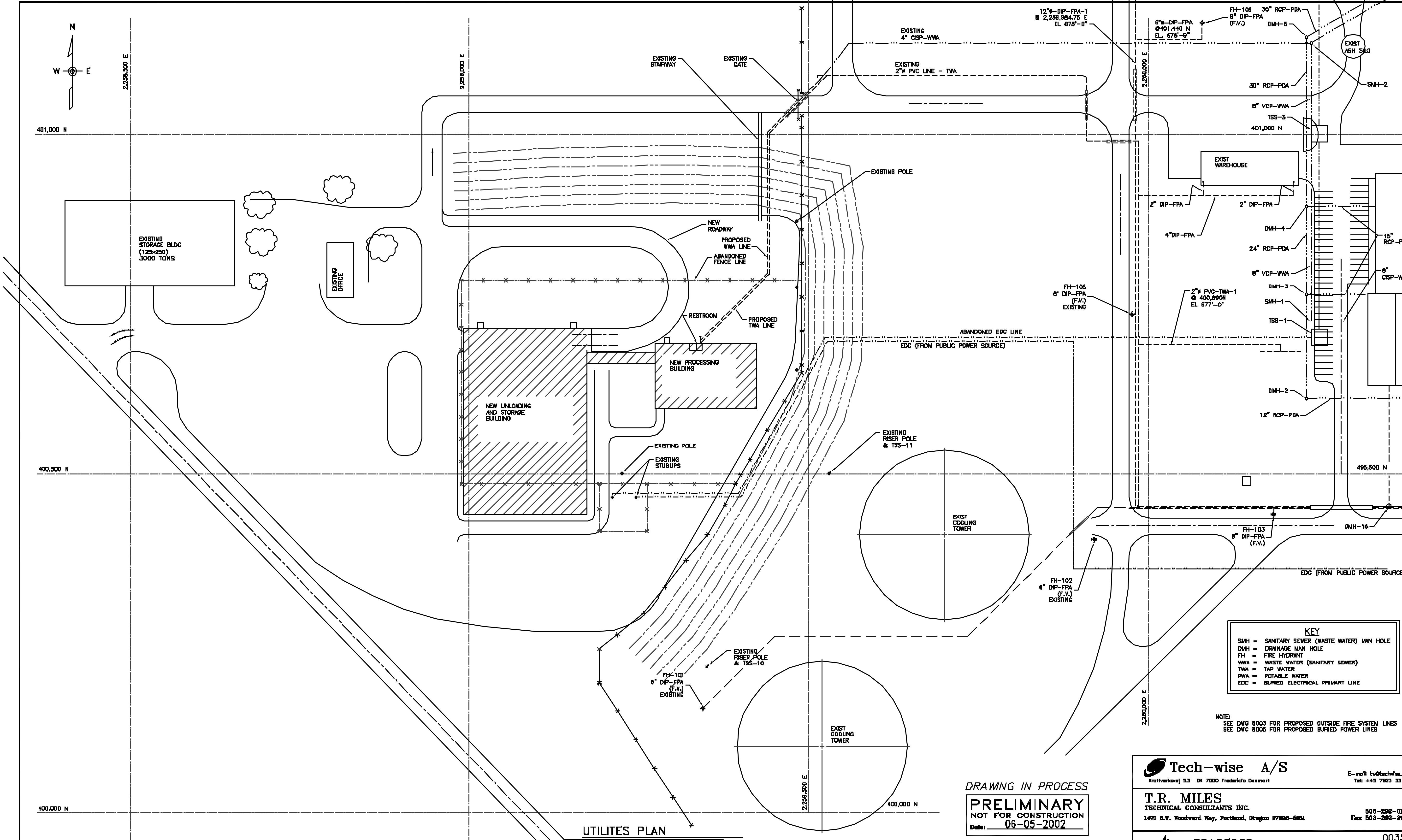
DES	K.W.
CHK	
Date	04-02-02
Scale	1"=60'-0"

UTILITY PLAN - EXISTING SITE

FOR CHARLTON VALLEY BIOMASS PROJECT
OTTUMWA, IOWA

DWG No. 732-8001 REV C



KEY

SMH = SANITARY SEWER (WASTE WATER) MAN HOLE
DMH = DRAINAGE MAN HOLE
FH = FIRE HYDRANT
WWA = WASTE WATER (SANITARY SEWER)
TWA = TAP WATER
PWA = POTABLE WATER
EDC = BURIED ELECTRICAL PRIMARY LINE

NOTE:
SEE DWG 8003 FOR PROPOSED OUTSIDE FIRE SYSTEM LINES
SEE DWG 8006 FOR PROPOSED BURIED POWER LINES

DRAWING IN PROCESS

PRELIMINARY
NOT FOR CONSTRUCTION
Date: 06-05-2002

REV.	DATE	DESCRIPTION	BY
A	6/6/02	UPDATED	DN

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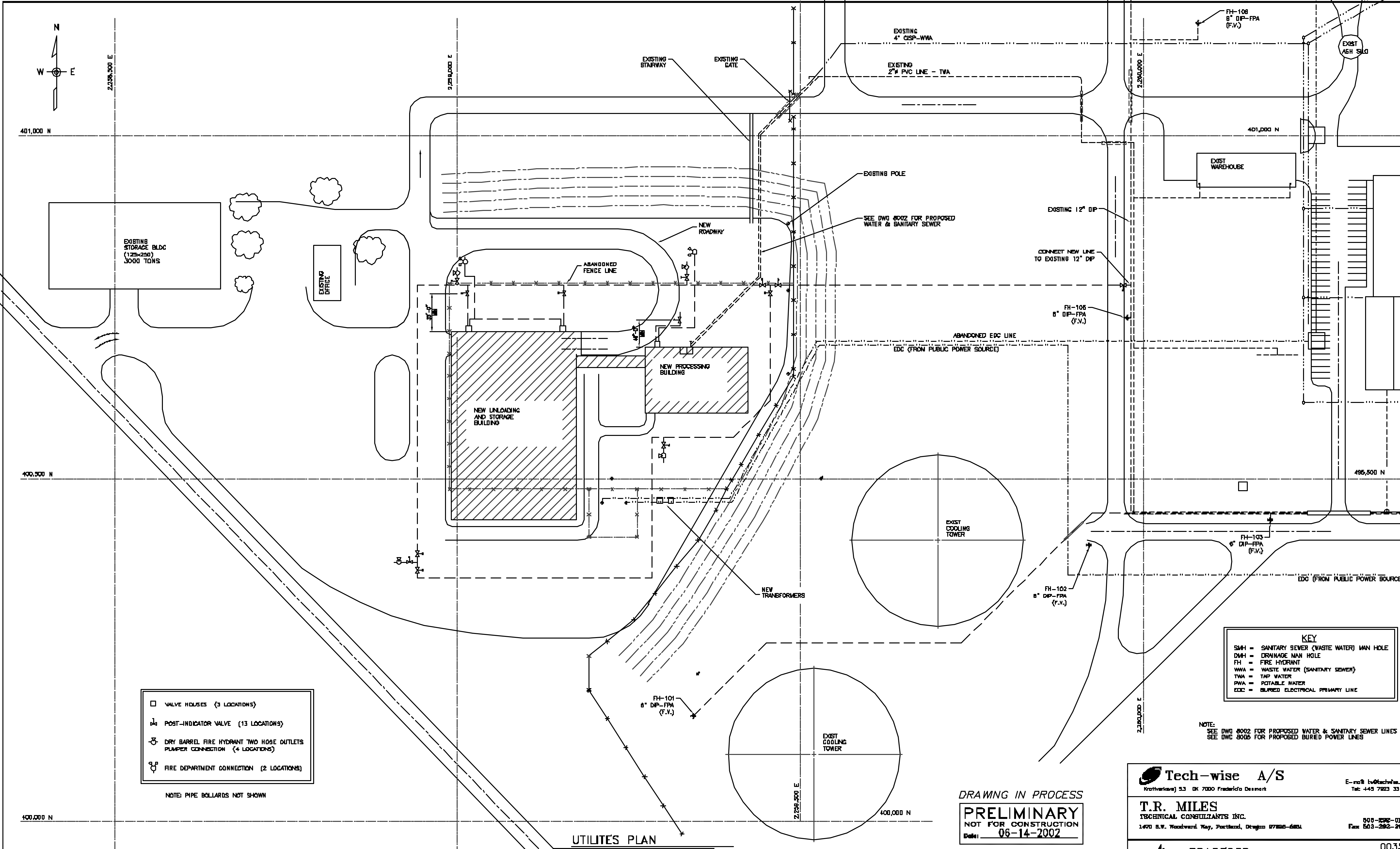
00352

DES BCC	UTILITIES PLAN – WATER & SANITARY SEWER 25 TPH AUTOMATED SYSTEM		
CHK			
Date 05-31-02	FOR CHARITON VALLEY BIOMASS PROJECT OTTUMWA, IOWA	DWG No. 732-8002	REV A
Scale 1"=60'-0"			



PRELIMINARY
NOT FOR CONSTRUCTION
Date: 06-14-2002

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BRADFORD CONRAD CROW ENGINEERING CO.
CIVIL • STRUCTURAL • MECHANICAL ENGINEERS
10160 SW NIMBUS AVE SUITE J3 TIGARD, OR 97223 PH (503) 639-6601 FAX 639-6261

00352

REV.	DATE	DESCRIPTION	BY
A	06-14-02	UPDATE AND ADD ELECTRICAL TRANSFORMERS	DLG

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PLOT: 06-14-2002 11:04:52AM DLG
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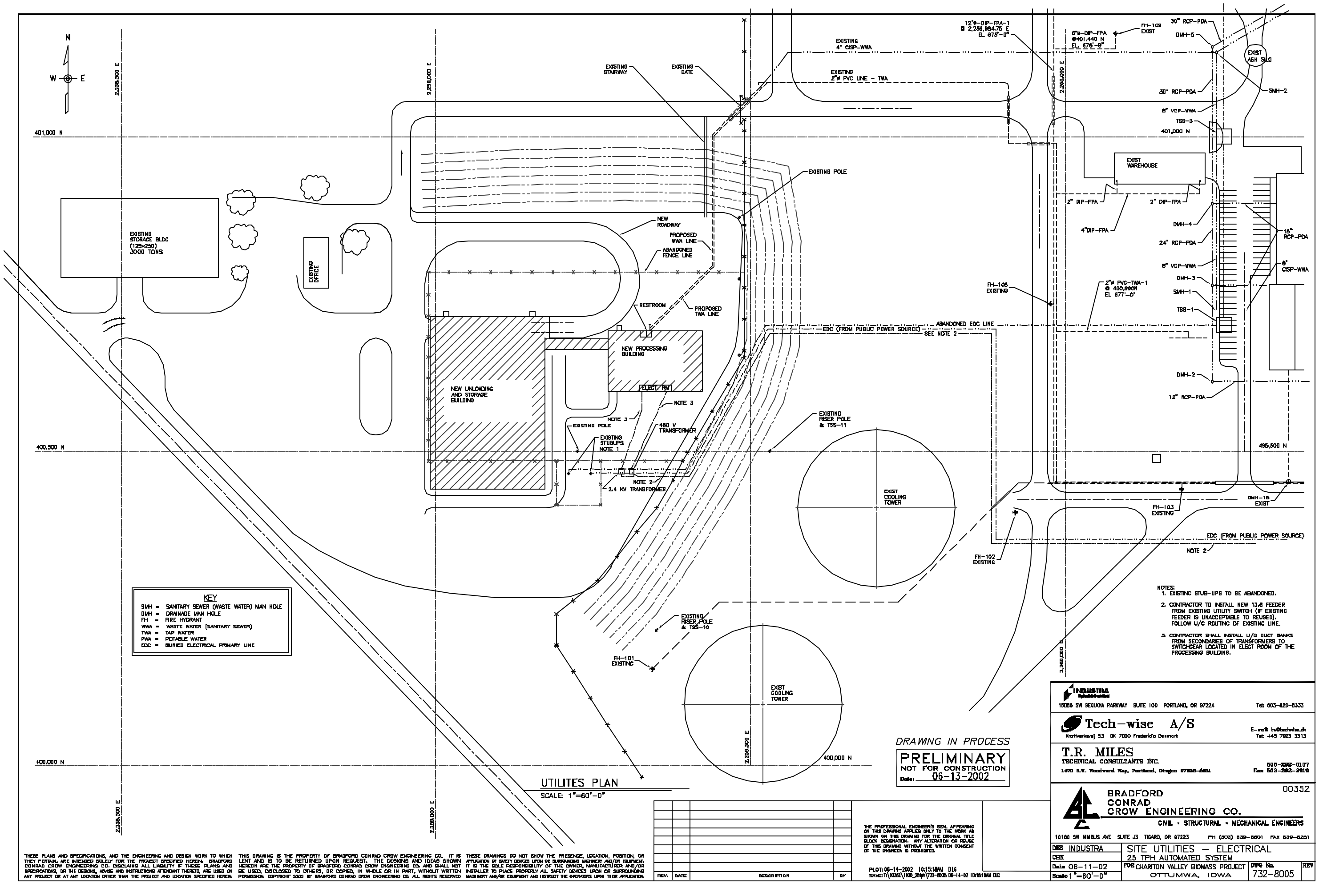
DES BCC	UTILITIES PLAN – OUTSIDE FIRE SYSTEM 25 TPH AUTOMATED SYSTEM
CHK	
Date 06-05-02	FOR CHARITON VALLEY BIOMASS PROJECT OTTUMWA, IOWA — DWG No. 732-8003 — REV A
Scale 1"=60'-0"	



KEY

SMH =	SANITARY SEWER (WASTE WATER) MAN HOLE
DMH =	DRAINAGE MAN HOLE
FH =	FIRE HYDRANT
WWA =	WASTE WATER (SANITARY SEWER)
TWA =	TAP WATER
PWA =	POTABLE WATER
EDC =	BURIED ELECTRICAL PRIMARY LINE

NOTES:
1. EXISTING STUB-UPS TO BE ABANDONED.
2. CONTRACTOR TO INSTALL NEW 13.8 FEEDER FROM EXISTING UTILITY SWITCH (IF EXISTING FEEDER IS UNACCEPTABLE TO REUSED). FOLLOW U/G ROUTING OF EXISTING LINE.
3. CONTRACTOR SHALL INSTALL U/G DUCT BANKS FROM SECONDARIES OF TRANSFORMERS TO SWITCHGEAR LOCATED IN ELECT ROOM OF THE PROCESSING BUILDING.

UTILITES PLAN
SCALE: 1"=80'-0"

DRAWING IN PROCESS
PRELIMINARY
NOT FOR CONSTRUCTION
Date: 06-13-2002

INDUSTRA
15005 SW BEQUON PARKWAY SUITE 100 PORTLAND, OR 97224 Tel: 503-620-5333

Tech-wise A/S
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1470 S.W. Woodward Way, Portland, Oregon 97225-5651 503-292-0107 Fax 503-292-2919

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10180 SW NIMBUS AVE SUITE J3 TIGARD, OR 97223 PH (503) 639-8601 FAX 639-8261

DES: INDUSTRA	SITE UTILITIES — ELECTRICAL	
CHK	25 TPH AUTOMATED SYSTEM	
Date: 08-11-02	FOR CHARITON VALLEY BIOMASS PROJECT	DWG No. 732-8005 REV
Scale: 1"=60'-0"	OTTUMWA, IOWA	

REV.	DATE	DESCRIPTION	BY

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PLOT: 08-14-2002 10:15:14AM DIG
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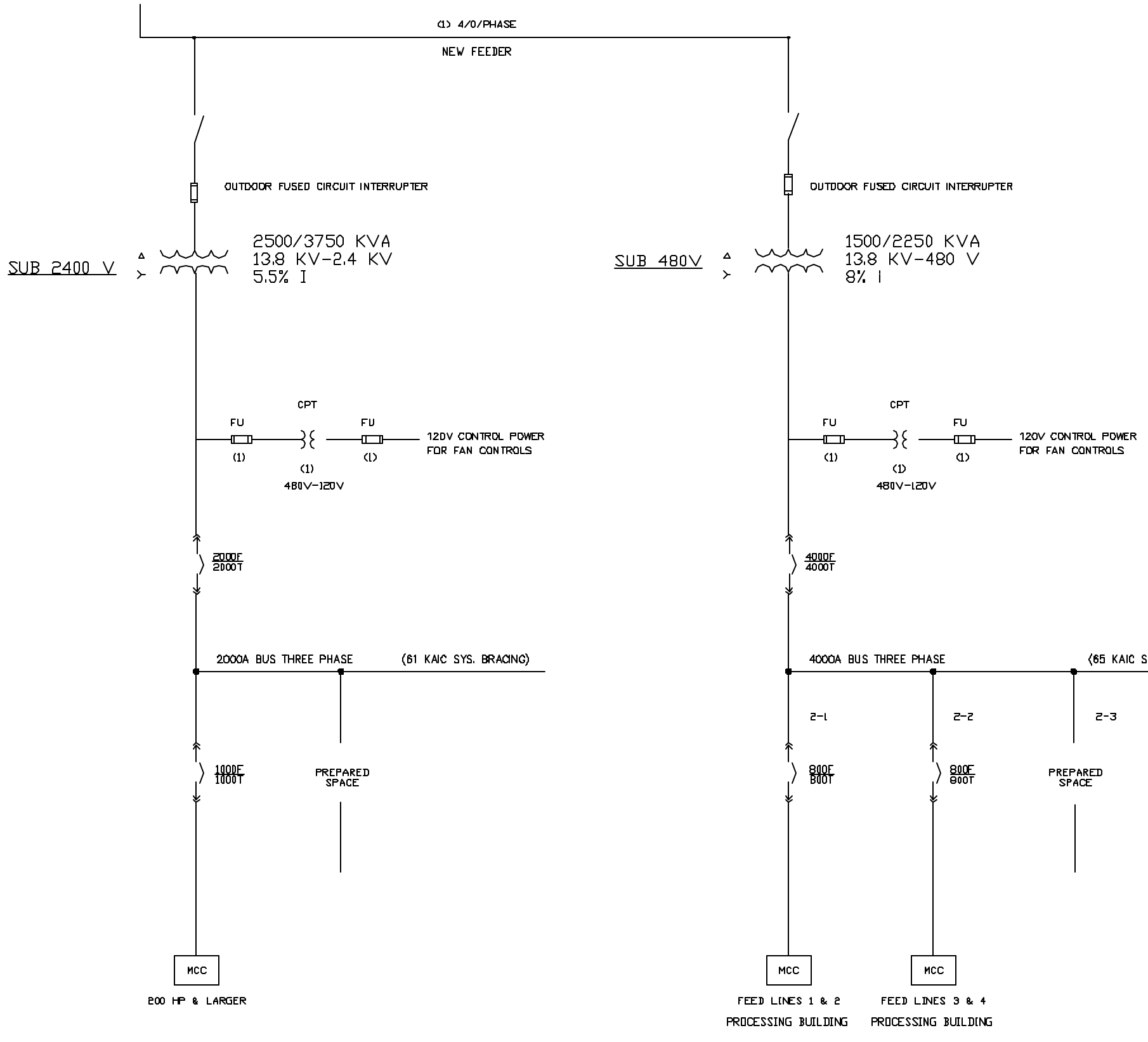

NOTES:

1. TRANSFORMER KVA LISTED ARE PRELIMINARY, CONTRACTOR TO SPECIFY TRANSFORMER KVA, CIRCUIT BREAKER AND FUSES PER FINAL MOTOR LIST AND ELECTRICAL DESIGN.
2. CONTRACTOR SHALL PROVIDE METERING AS REQUIRED PER THE ELECTRICAL EQUIPMENT SPECIFICATIONS.

DRAWING IN PROCESS

PRELIMINARY
NOT FOR CONSTRUCTION
Date: 06-13-2002

REV.	DATE	DESCRIPTION	BY

INDUSTRA
15066 SW BEQUOIA PARKWAY SUITE 100 PORTLAND, OR 97224 Tel: 503-620-5333

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E-mail: tw@techwise.dk
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10180 SW NIMBUS AVE SUITE J3 TIGARD, OR 97223 PH (503) 639-8601 FAX 639-8261

DES	INDUSTRA
CHK	
Date	08-10-02
Scale	1=1

ONE LINE DIAGRAM
25 TPH AUTOMATED SYSTEM
FOR CHARITON VALLEY BIOMASS PROJECT
OTTUMWA, IOWA

DWG No. 732-8006 REV

Appendix 2
Equipment to be Procured – Preliminary Equipment Specifications

Table of Contents for Appendix 2

Section 1. Storage and Reclaim

1.1 Storage Barn Requirements

The switchgrass is to be stored in two bays each having a storage capacity of minimum 1,776 bales (for 12-bale courses) and maximum 2,072 bales (for 14-bale courses) or a total of minimum 3,552 bales and maximum 4,144 bales. The storage capacity is based on bales with a height of 3 ft., width of 4 ft. and length of 8 ft. having an average weight of 1,000 lbs. The storage capacity in one bay is equal to 888 tons or 71 hours of operation at a consumption of 12.5 tph when storing eight bales high and in six rows. When storing in seven rows, the capacity is 1,036 tons equal to 83 hours of operation.

Two roadways shall lead from the end of the two storage bays and are separated lengthwise by a catwalk with the vacuum cleaners for the trucks. Each storage bay holds in average 18.5 courses, stacked in eight layers. The bond principle (see drawing 732-2003 in Appendix 1 for an illustration of the bond principle) means that every second layer has an offset; the two bottom layers hold 20 courses, the next two layers hold 19 courses, layers 5 and 6 hold 18 courses and the two top layers holds 17 courses. This makes up an average of 18.5 courses.

In this layout (see drawing 732-3001 in Appendix 1 for illustration), the storage only consists of one pile in each of the bays. This is done to maximize the utilization of the gross area of the building. Dividing the storage into multiple piles due to differences in the number of rows will decrease the capacity due to the loss of bales in the ends of each pile (bond principle). To achieve the optimum use of the storage (number of bales per square feet) the unloading area is situated at the end of the storage bay although the average running distance of the crane during unloading will increase. However, the time for transporting the bales through the bays shall only be a minor part of the total unloading time. The unloading time in total shall thus not be affected significantly.

1.2 Crane

The storage cranes are designed as traverse cranes with a span of approx. 82.5 ft. The distance between the columns is calculated to be 84.8 ft.

The storage cranes shall be able to grip and lift a layer of 14 pcs. in one lift, i.e. a lifting capacity of 28,000 lbs net.

The crane is supplied with an overload alarm.

The crane traverse is dimensioned according to the lowest possible dead weight and max. 1/1000 of the span in deflection at max. load.

Each crane is supplied with a lifting yoke, equipped with 7 switchgrass tongs.

The supplier is to make a design and a location of all components that will disturb the view of the operator as little as possible.

The steel construction, roadways and machinery of the crane are to be calculated according to the standards in force for cranes: ASME or similar. In the bid, the supplier is to state the standards and classifications used.

The trucks will be positioned according to the front edge of the front bale, implying that the first switchgrass of the layer will be placed approx. 10 ft. from the wall of the storage bay.

1.2.1 Unloading of the Trucks

Usually, a truck with 42 bales will be delivered to the plant (three 14-bale courses) . Occasionally, 36 bale trucks will arrive with three 12-bale courses. The crane shall be able to lift both 12 and 14 bale courses without having to exchange lifting equipment. For every unloading situation, the crane shall be able to unload three 12- or 14-bale courses within 15 minutes from the start of truck unloading until the crane is back at the start-out position. The crane must also be able to take only half a layer without this causing any crane stability problems.. In this case, the crane shall be able to put another half layer next to be first by means of "Manual Operation by the Operator".

It must be expected that the truck driver might have difficulties switching to place the trucks parallel with the crane. It shall therefore be possible to continue the wire guides to the yoke at one end, 8 inches. This kind of operation will apply in connection with "Manual Operation by the Operator" and Semi-automatic Operation by the Operator".

1.2.2 Lifting Yoke

Two double-groove wire drums with four departing wire parts are fixed on the crane traverse and these lift synchronously at each end of the lifting yoke. The suspension is formed with anticurves in 14 wire parts to optimize the lifting function and at the same time allowing the crane to operate.

The lifting yoke is supplied with two minor wagon yokes which have three tongs fastened on the front wagon yoke in the driving direction, and four tongs on the back wagon yoke.

The distance between the tongs of the wagon yokes shall be 7 ft. 6 inches.

It shall be possible to displace the two wagon yokes with tongs in longitudinal direction of the traverse crane by means of hydraulic cylinders and guides in the lifting yoke.

It shall be possible for both wagon yokes to move separately in relation to the lifting yoke, so that they can be placed above the center of bale no. 2 and bale no. 5, respectively, counted from the front of the truck.

It shall be possible for the front wagon yoke (in the trucks driving direction) to move 1 ft. as compared to a load of "maximum length".

The back yoke should correspondingly be able to move +/- 16 inches, where + is the in the driving direction of the truck.

Thereby it will be possible to make a correct grip, even if the lengths of the switchgrass bales vary.

The two wagon yokes are to automatically return to their normal position after placing the switchgrass bales in the storage or at the twin bale chain conveyor. The crane operator is thus only to correct for deviations of the length of the truck or of the switchgrass bales.

In case the truck to be unloaded has only 6 pair of bales, the wagon yokes are pulled closer together so that the three front switchgrass tongs and the three back tongs grip the 12 close-lying switchgrass bales on the truck body.

The seventh and last switchgrass tong then grips into the empty air behind the semi-trailer.

The lifting yoke is to be dimensioned according to the lowest possible dead weight. The hanging points of the wires have to be as near as possible to the quarter points of the weight distribution at full load. The lifting yoke is to be dimensioned for max. 1/1000 of the span in deflection. The situations with the two wagon yokes apart from each other and together are to be consider with worst case as dimensioning.

1.2.3 Switchgrass Tongs

The switchgrass tongs are constructed with a horizontal, linear gripping movement with a closing function towards a fixed stop at the side towards the storage. Thereby, possible deviations of the breadth of the switchgrass bales are set off, so that one side will always be in line.

The tong with a fixed stop (towards the storage) shall have a nominal linear movement of ½ × (19.7 inches less the thickness of the tongs). It is thus ensured that the tongs will center between the rows of switchgrass when collecting from the storage.

The switchgrass tongs are designed to take 3' × 4' × 8' bales in breadth next to each other, i.e. the tongs in gripping position shall have a distance of 96 inches nominal, max. 100 inches, min. 88 inches.

Further reference is made to the option for lifting of Hesston bales where the increased height is to be considered when the tongs are to grip two bales placed next to each other.

Within these measures of the switchgrass, the tongs shall be able to hold on to the switchgrass bales without dropping them and without deforming them permanently.

Hydraulic cylinders shall activate the switchgrass tongs. The switchgrass tongs are each supplied with a sensor to detect if the tongs drop a switchgrass bale.

1.3 Twin Chain Bale Conveyor

The switchgrass conveyors in the storage are to be twin bale chain conveyors, implying that they can transport the switchgrass bales in pairs with the long side turning towards each other.

The storage cranes load 14 (12) switchgrass bales at a time to the switchgrass conveyors, place them in pairs next to each other and 7 (6) bales in a row. The maximum weight of 14 switchgrass bales is 28,000 lbs net. When unloading, the weight of the crane yoke is to be added, so that the max. load at the twin bale chain conveyor must be expected to be 46,740 lbs.

At the twin bale chain conveyor where the cranes put the switchgrass bales, it must be expected that the switchgrass bales expand across, when the crane tongs let go of the switchgrass bales. The transverse chains are thus pulled away from the middle and a chain guide is to allow for a chain displacement transverse of the twin bale chain conveyor without the chain "capsizing". For the same reason, it should be considered to leave out carriers at this conveyor and instead raising the chain in relation to the twin bale chain conveyor to maintain a stable transport of the switchgrass bales. During transport, the chain is to pull towards the middle of the conveyor by itself - by means of the chain guide - to obtain clearance for the switchgrass bale expanding before loading a new layer of switchgrass. The chain guide is to be mounted by means of materials reducing the friction between chains and guide.

The capacity of the twin chain conveyors shall be 25 tph of switchgrass.

When a switchgrass bale pair has been transported to the transfer vehicle from the twin bale chain conveyor, the twin bale chain conveyor is still running until a new switchgrass bale pair is immediately in front of the fire gate. This means that new bales shall constantly be ready for transport on the transfer vehicle.

Considering fire prevention, it is important to separate the driving of switchgrass from the storage and the transfer vehicle:

- Experience shows that the fire runs on top of the switchgrass bales, thus working as a fuse. A separation will make a break to this fuse.

- It shall be possible to close the fire gates freely in case of a fire.

The space between the conveyors in the section at the fire gates are closed by means of a smooth plate, so that possible switchgrass waste is pushed away after each transport of a new switchgrass bale and so that the fire gate can close tightly toward possible loose switchgrass.

In case of a fire alarm, an initiated transport of a switchgrass bale pair through the gates shall continue in order to clear the fire gates as soon as possible.

The fire gates will be part of another supply whereas the dimensions of the twin bale chain conveyors are to be adjusted to the building measurements of the gates.

1.4 The Moisture and Weight Measurement System

The moisture measurement system shall be able to measure between 9% and 25% relative moisture in all bales. The accuracy must be better than ±1% relative moisture.

The system must be supplied with devices for verifying the measurement. The devices must show an accuracy of ±2% of nominal value. The devices must correspond to 10, 20 and 27% moisture.

1.5 The Storage Management System (SMS)

1.5.1 Program Structure

A structured program development is used.

The users of the SMS are expected to be engineers or crane operators with knowledge of the process. The user interface is to be based on menus.

The system is to use a stable operating system, which is capable of handling several processes (PLC-1, PLC-2, card-reader-1, card-reader-2, presentation) at the same time. The SMS is to be developed by means of standard products, e.g. ANSI-C, TCP/IP and SQL.

Program documentation is to be prepared, comprising:

1. System diagram, showing the program in its surroundings, communication with disk, printers, card readers, file server, PLCs and operator.

2. A functional description of the program by means of data flow diagrams and supplementary plain text.

3. Program survey of the processes/modules of the program and how they communicate.

4. Documentation in the program in the form of relevant comments and description of input/output in functions.

5. An updated version of the requirement specifications.

1.5.2 Definitions

The system is to be designed for adding new information on suppliers and switchgrass and applying this new information in the existing functions of the system.

Supplier information

Supplier number	:	Figure (0-99999999)
Contract number	:	Figure (0-999999)
Supplier address	:	Text
Active supplier	:	YES/NO
Carrier number	:	Figure (0-9999)
Carrier address	:	Text
Zone	:	Figure (0-99)

Switchgrass information

Type of switchgrass	:	Figure (0-99)
Contract number	:	Figure (0-999999)
Supply number	:	Figure (0-9999)
Manual entering	:	YES/NO
Layer no. on truck	:	Figure (1-2)
Bay	:	Figure (0-9)
Weight	:	Figure (0-99999) lbs
Moisture (6/7 pair of bales with 3 measurements each)	:	Figure (0.0-99.9) %
Number of switchgrass bales	:	Figure (0-99)
Supplier number	:	Figure (0-9999)
Carrier number	:	Figure (0-9999)
Date and time for delivery	:	YYYY-MM-DD tt:mm:ss
Position at storage (x, y)	:	Figure x (0-99999) y (0-99999)
Date and time for picking up	:	YYYY-MM-DD tt:mm:ss
Position at storage (x, y)	:	Figure x (0-99999) y (0-99999)

Regarding the position at the storage, a system is agreed upon with the supplier of the crane supplier, where only positions for each layer of switchgrass consisting of 12/14 bales are exchanged. Positions are made up by traverse (length position 1-39) and height (1-8).

1.5.3 Functional Requirements

The specifications of the functions listed in *The Functions of the System* (section 7.2.3.1 of the narrative) are stated here.

Specifications of input, function and output are given for each function.

Please note! As this specification is not adequate, the supplier is to clarify and maintain this description as agreed upon with the Owner. The supplier is to divide the described functions into more part functions and possibly add new functions to illustrate the current system.

Transfer switchgrass supplies to backup medium

Input: Start-date, end-date.
Switchgrass supplies.

Function: The function generates an ASCII file comprising the switchgrass supplies of the latest 24 hours. The file is stored at the backup medium. The file name is to consist of year, month and date to be able to distinguish it from the other days.

This function automatically takes place once every 24 hours or when requested by the user. When files are generated on request, the start and end date as well as filename are to be stated.

Output: Information concerning switchgrass supplies is sent to backup medium.

Receive information from card reader

Input: Supplier number, carrier number and switchgrass type from card reader.

Function: Before the supply of switchgrass can begin, the truck driver is to enter the supplier number via the card reader or keyboard, after which he enters his carrier number and switchgrass type. This information is verified by comparison to already known supplier information in the system. If the supplier and carrier are unknown, a message is sent to the card reader display. If the supplier and carrier are accepted, a message is sent to the card reader display. Then a message is sent to the crane that the unloading may begin.

This function is done on request by the card reader.

Output: Information to card reader display.
Information to crane PLC.
Information regarding supplier number is registered.

Send receipt to card reader

Input: Supplier number, carrier number and switchgrass data.

Function: When the unloading has been finalized, the crane operator gives a message to the SMS, which makes a receipt of the supplied switchgrass to the truck driver. The receipt is printed out from the card reader printer.

This function is done on request by the crane operator via PLC.

Output: Receipt to the truck driver via the card reader printer.

Receive/send information to crane

Input: Position, moisture, weight, switchgrass in/out.

Function: On request of the crane PLC, this function is to send/receive information on the switchgrass taken into and out of the storage.

The storage management system is to approve of moisture and weight - to assign available locations in the storage for placing the switchgrass - receive positions where the crane has placed the switchgrass - assign locations for the next layer of switchgrass to be taken out of the storage - receive position where the crane has taken switchgrass out of the storage, etc.

Based on the information received from the crane PLC, the information on the current stock of switchgrass and the total of supplied switchgrass for storage and consumption is maintained.

These functions are done on request by the PLC.

Output: Switchgrass rejected/accepted.
Switchgrass in/out.
Updating of stock.
Updating of total supplied switchgrass.
Updating of total consumed switchgrass.

Presentation and handling of data

Input: Position, moisture, weight, supplier, carrier, criteria etc.

Function: Data are to be presented graphically and in reports for bay 1 and 2. The stock is to be presented graphically on a screen. The function is to be able to print reports on the current stock and to report on the total supplied and consumed switchgrass quantities. The reports are to include weighted amounts and weighted amounts adjusted to a dry

switchgrass basis. It is to be possible to set up selection criteria for the data included in reports, like limit values, time periods (day, month, year) and supplier.

These functions are done on request of the user.

Output: Graphical survey of storage stock is shown on screen.
Report on storage stock is printed.
Report on supplied switchgrass is printed.
Report on consumed switchgrass is printed.
Report on supplier's supply is printed.

Operator parameters/operation

Input: Information on supplier and carrier.
Limit values for moisture and weight (max., min., average)
Adjustment of storage stock.
Area to be emptied first.
Area to be closed off.

Function: It is to be possible for the crane operator to enter supplier and carrier information together with limit values for moisture and weight to be used for evaluation of the switchgrass supplied.

If there are discrepancies in the SMS's storage stock, it shall be easy to correct these.

It shall be possible for the crane operator to inform the SMS of which areas of the storage bay to empty first. Furthermore, it shall be possible for the crane operator to close off areas of the storage bay.

These functions are done on request of the user.

Output: Information on supplier and carrier are updated.
Limit values for moisture and weight are updated.
Information on storage stock is updated.
Information on area to be emptied is updated.
Information on area to be closed off is updated.

1.5.4 Other Requirements to the SMS

1. The system shall allow for adjustment of summer/winter time.

2. The SMS is to be updated each time switchgrass is taken into/out of the storage.

3. Card readers and printers shall be able to operate under the conditions of the storage bay (dust, moisture and temperature).

4. All inputs from a user are to be verified related to possible failures.

5. The system is to be designed to be as tolerant to failures as possible. The system is to be analyzed for all things which might go wrong and how the system is to respond. The system shall be able to save and show all known failure situations, stating date and time.

   In the following some failures, which might appear in the system and which are therefore to be taken into account, are presented.

   How is the system to handle failures if:

   a. The crane operator enters incorrect information;
   b. The truck driver uses a wrong supplier card in the card reader;
   c. The data transmission is going wrong;
   d. The communication with external units (PLC, network, printer, card reader, backup medium, etc.) goes wrong;
   e. Information on switchgrass is incorrect;
   f. Information on storage stock is incorrect.

6. After hand-over, the Owner is in possession of all rights of the system including software and source text.

1.6 Other Requirements

The twin bale chain conveyor shall be designed as a closed construction applying chains. The closing of the conveyors is made with mild steel plates to make the switchgrass waste stay with the bale during transport to the processing lines and to prevent switchgrass waste from falling into shafts, gear wheels, drives, etc.

The drives and tightening devices of each twin bale chain conveyor are to be designed according to the total length of the chain, to obtain an optimum lifetime of the chain, and to increase the intervals between the tightening.

The chains shall have high fracture strength and may not be galvanized. Possible carriers on the chain are to be mounted or welded on when delivered from the chain supplier.

The chain is mounted with carriers or similarly ensuring the transport of the switchgrass. The scope and choice of carriers are to appear in the bid.

All rotating shafts, tightening wheels, guides, drives, etc. shall have an extra covering to protect against personal injuries and to provide cover against switchgrass entry. These devices must be easy to disassemble.

Drives shall be directly shaft mounted gear motors without a V-belt or chain drive. Gear motors are to be dimensioned for frequent and direct start/stop.

All shaft seals and drives are to be suited for use in dusty surroundings and drives as well as bearings shall require only minimum maintenance.

In general, it shall be possible to process all received switchgrass bales in the following transport and processing equipment towards the firing to the boiler.

Wire trays have to be covered and automatic greasers shall be used, where possible, to prevent dust from entering bearings.

Section 2. Processing Equipment

2.1 Delivered Switchgrass Criteria Required

All unloading, transporting and processing equipment is to be designed for handling switchgrass bales with the following data:

Weight (as received):	745 – 2000 lbs.
Dimensions, nominal:	$w \times h \times l = 48 \times 51 \times 94.5$ inches (Hesston)
Dimensions, design:	$w \times h \times l = 51 \times 53 \times 108$ inches

Further details on fuel specifications are located within section 5.7 of the narrative.

2.2 Transfer Vehicle

By means of the twin bale chain conveyor the switchgrass is transferred in pairs.

The transfer vehicle is to take the switchgrass bales in pairs from the twin bale chain conveyor and place the bales one by one at one of the single chain conveyors. A spreader function is thus to be incorporated in the transfer vehicle to separate the switchgrass bales and to transport each of the switchgrass bales onto a random single chain conveyor.

The transfer vehicles are to be on a transverse line extending from the double chain conveyor to the four switchgrass process lines.

The maximum total load of 25 tph equals 67 bales per hour at minimum design weight. Therefore, the cycle of the transfer vehicle from receiving a pair of bales, feeding them to two random receiver conveyors and returning to the twin conveyor ready for receiving another pair of bales is 1.8 minutes.

It is the responsibility of the supplier to incorporate sufficient safety in the speeds of the transfer vehicle to ensure distribution of the switchgrass bales in step with the consumption at each treatment line without any delay in the supply.

The vehicle lanes are to be equipped with electrical stops and buffer stops.

2.3 Conveyor System

The switchgrass bales are transported from the transfer vehicle on to a receiver conveyor where it stops and awaits a clear signal from the subsequent collection conveyor.

The collection conveyor before each switchgrass process line runs faster than the intermediate conveyors (in front of the de-twiner). The switchgrass bales are therefore to be placed close to each other before the twine removers. The collection conveyors must be able to run at variable speed, i.e. the speed is high when the switchgrass bales are collected where after the speed is lowered to be only slightly more than the speed of the intermediate conveyors.

The bales are thus to lie in an uninterrupted line at the collection conveyors and onto the intermediate conveyors in the subsequent supply.

The conveyors and the control of these are to be coordinated in such a way that a switchgrass bale, which is unloaded from the transfer vehicle, is transferred onwards and ends up towards the line of bales.

It is the responsibility of the supplier to make the conveyors according to the required specifications so that the total transport onto the subsequent supply consisting of intermediate conveyors/de-twiners and switchgrass de-balers runs in an optimum way.

2.4 De-twiner

If requested by the downstream equipment, the bid shall include a de-twiner.

The de-twiner shall be able to receive 17 whole bales per hour with specifications as stated in section 2.1 of Appendix 2. Up to six plastic twines hold the bales together. The de-twiner shall be able to remove 99.0% of all twines, which were undamaged when going into the de-twiner.

After the twine removal, the bales shall be transferred to the de-baler in an appropriate way to keep the switchgrass waste and dust problems at a level as low as possible and within the recommended limit as appears within section 5.5 of the narrative.

It shall be possible to choose between having the twines sorted out or having them cut to pieces of less than 8 inches and feeding them with the switchgrass to the boiler.

2.5 De-baler and Belt Conveyor

The de-baler receives the switchgrass in bales with or without twine according to the machine requirements to fulfill the operation requirements.

It shall be possible to adjust the feeding conveyor upstream the de-baler to a switchgrass flow between 10 and 100% by means of continuous control.

It shall be specially noted the de-baler does not require the twines to be removed from the switchgrass bales, and the de-baler can handle other sizes of switchgrass bales than the bales described.

The de-baler shall be integrated with a belt conveyor with the purpose of leveling the switchgrass flow.

The switchgrass de-baler is to be supplied with a combined dust collection system, which the sizing equipment can be connected to, if necessary. The dust collected is to be sent through the system together with the switchgrass.

The de-baler shall be mechanical and shall shred the switchgrass to a uniform mass of loose switchgrass. In the bid, the supplier is to inform how the uniformity of the switchgrass is demonstrated by means of tests.

The switchgrass de-baler shall be equipped with fire detection (thermal) and an automatic fire extinguishing system.

Attached in the back of this section are vendor specification sheets of the de-baler used as a basis of design.

2.6 Stone Separator

The de-baler and belt conveyor shall be integrated with a foreign body separator, which can remove foreign bodies with another density than switchgrass, like e.g. metals, stone or wood.

The foreign body separator shall be able to separate any stone or metal foreign body, longer than 0.8 inch and with a total volume of more than 0.3 in^3.

2.7 Sizing Equipment (Hammermill)

The switchgrass grinder is to receive the shredded switchgrass from the foreign body separator and all particles must be ground through a screen size of 2 inches or less.

The grinder shall supply an even flow of cut switchgrass and in the bid, the supplier is to state how this evenness is demonstrated by means of tests.

The principle of the cutting is free of choice.

The grinder shall be equipped with fire detection (thermal) and an automatic fire extinguishing system.

Information should be given as to whether the grinder can handle that pieces of plastic (nylon) twine is mixed with the switchgrass and thus also comes through the grinder.

Attached in the back of this section are vendor specification sheets of the hammermill used as a basis of design.

2.8 Other Requirements

The machines are to be protected in such a way that it is possible to keep the dust emission at a level as low as possible. The protection is to be very service friendly and it must be possible to remove the protection easily and without use of tools.

The de-baler is to be equipped with a rubber skirt or similar which closes tightly around the bales when they are fed into the machine.

Where mechanical securing of gears and motors against overload is necessary, hydraulic couplings are to be used.

All gears should be mounted directly on shafts.

All shafts are to be equipped with rotation guards in the non-operated end of the shaft.

All power transfers are to be made in such a way that in case of momentary blocking of the machinery, no ruptures of the mechanical components will take place.

In the machines where blocking may appear, reverse turning must be possible if this will facilitate cleaning and restart.

Vendor Specification Sheets for De-baler and Hammermill

Technical Specifications M&J 4000 Cutting Table

Overall dimensions:	Length:		4000 mm
	Width :		2300 mm
	Height:		1250 mm
Weight:	In total:		17.000 kg
Cutting area:	Length:		2390 mm
	Width :		1743 mm
Hopper:	Length in top:		3700 mm
	Width in top :		2000 mm
	Height :		700 mm
	Volume in hopper:		4 m³
Open area:	Distance between knife beams:	2x6	243 mm
		2x8	150 mm
		2x10	94 mm
Rotating knives:	Welded on shaft		2x10
	Forward tips on knife		2
	Backward tips on knife		2
	Width		80 mm
Counter blades:	Welded on frame		12/16/20 pcs.
Speed of shaft:	Forward/backward rotation, load dependent		16-40 RPM
	Adjustable max.		25-40 RPM
Main Bearings:	Roller bearings		2 per shaft
Hydraulic motors for shaft:	2 (two) Hägglunds CA 210		
Central lubrication system:	Automatic lubrication of bearings with control of grease supply.		
Grease consumption:	8 g/hour		
Paint:	RAL 2011 - orange		
	Corrosion class 2		

Technical Specifications M&J 4000 S Power Pack

Dimensions:	Length: Width : Height:	2250 mm 1350 mm 2008 mm
Weight:		4,800 kg
Min. service area:	"around the unit", recommended:	1000 mm
Drive principle:	Double hydrostatic transmission, asynchronous shaft drive with horse power control.	
Motor:	2 x 132 kW WEG electric motor. 3x380-415V, 50 Hz	
Gearbox:	Stiebel type 4381	
Hydraulic pump:	Denison P14	
Cooling capacity installed:	Hydraulic oil cooler	75 kW (in total)
Standard:	Water cooler, min max. inlet water temp. max outlet water temp.	4 m³/h of water 30 ºC 45 ºC
Optional:	Air cooler, cooler dimension, Airflow	2 x (1087x998x665) mm 2 x 3.0 m³/sec
Hydraulic tank:		600 L
Noise level:	88 ± 3 dB(A) at 1m distance	
Central lubrication system:	Brand: Lincoln	
Electrical panel:	Electrical panel with automatic star-delta switch, circuit breaker and thermistor monitoring for the electric motor. PLC controlled. IP54.	
	Dimension LxWxH Weight	2000x500x2000 mm approx. 700 kg
Paint:	RAL 2011 - orange Corrosion class 2	

Technical Specifications M&J 4000 S Chassis

Overall dimensions:	Length:	3420 mm
	Width :	2300 mm
	Height:	1750 mm
Weight:	In total:	3,500 kg
Height, cutting table to belt conveyor:		1100 mm
Conveyor:	Length:	3500 mm
	Width :	1200 mm
	Speed :	1700 mm/sec
	Bearings:	Ball bearings
	Drive motor:	Electric, 4.0 kW
Discharge:	Height:	652 mm
	Width :	1000 mm
Paint:	RAL 2011 - orange	
	Corrosion class 2	

Electrical Specification M&J 4000 S, standard

Voltage:	3 x 400 V + PE, 50 Hz	
Consumption:	Approx. 500 A when fully loaded	
Rated braking Icu:	35 kA	
Control voltage:	230 V AC / 24 V DC	
Principal motors	2 pcs. 132 kW each	
Rated current:	2 x 230 A	
Starter switch:	Direct, test value:	2300 A
	Star-delta, test value:	1500 A
	Soft starter, test value:	700 A
Temperature monitoring:	3 thermistors	

MULTIMILL 1400

Fine grinding hammermill

Type Multimill 1400

Application
Fine grinding hammermill for high-capacity production of fish feed, petfood and other fine grinding applications. The proven Multimill type in new design:

- High capacity particle size reduction
- Feed quality, technically correct product
- Feed ingredients nutritional value, protected by low temperature operation
- Reduced energy consumption
- Hinged dual screen frame concept
- The Multimill has 4 screen sections which allows for different screens increasing particle size flexibility, and minimizing costs of screens

Feeding system for uniform screen load
Material feeding in full grinding chamber length means higher controllability of particle size, uniform loading of hammers and screens, resulting in longer lifetime of wear parts.
The feeder system, available as double screw and separator or as pocket feeder with integrated separator, can be adjusted to all raw material types.

Low energy consumption - High performance
A special aerodynamic rotor design (pat.) leads the material directly out towards the screen where grinding goes on at the highest efficiency and lowest required energy.

Optional accessories

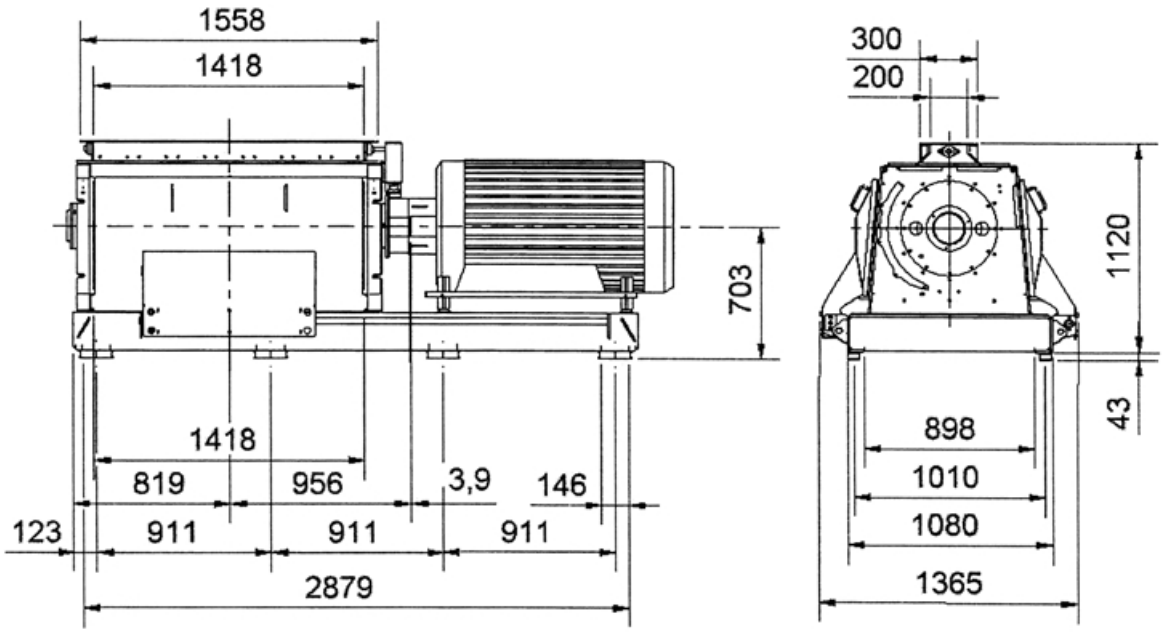
- Bearing temperature monitoring
- Grinding chamber temperature monitoring
- Vibration surveillance
- Rotor brake device
- Control unit

SPROUT-MATADOR

Multimill 1400

Fine grinding hammermill

Dimensions in mm



Technical data

Motor power	200-355 kW	(275-480 HP)
Motor 50/60 Hz	3000/3600 rpm	
Screen area	186 dm^2	(2884 In^2)
Number of hammers 6 mm	216 (4 x 54)	
Suction air, filter	9000 m^3/h	(5297 CFM)
Screen change	Operation stop	
Weight, motor excluded	2800 kgs	

Subject to change without prior notice

La Cour - ViGra 10/01

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Section 3. Pneumatic Transport System

3.1 Key Design Factors

To avoid pulsation in the switchgrass flow all bends in the line shall consist of circular pipes with a large radius.

According to the tests at Studstrup Power Plant the best results for the stability of the transportation have been with a final transport speed of not less than 65.6 ft/s. For the combustion it would be better to have a lower speed on the switchgrass and air entering the boiler. This could be obtained by having a larger diameter in the pipeline over the last few feet.

According to experiences with rotary airlocks for transportation of straw, the sealing between the rotor and stator shall be made of rubber.

Table 3.1: Design parameters for pneumatic conveyor system.

Item	**Unit**	
Pipe diameter	inch	10
Velocity in pipe at rotary airlock	ft/s	62.0
Velocity burner	ft/s	82.0
Design pressure, pipe	psi	7
Mass flow ratio (μ)	-	app. 1.0
Density, ground switchgrass	lb/ft^3	app. 7.0
Degree of filling in rotary air lock	%	40
Blower, power	HP	100
Blower, capacity	ft^3/s	42

Section 4. Switchgrass Burner

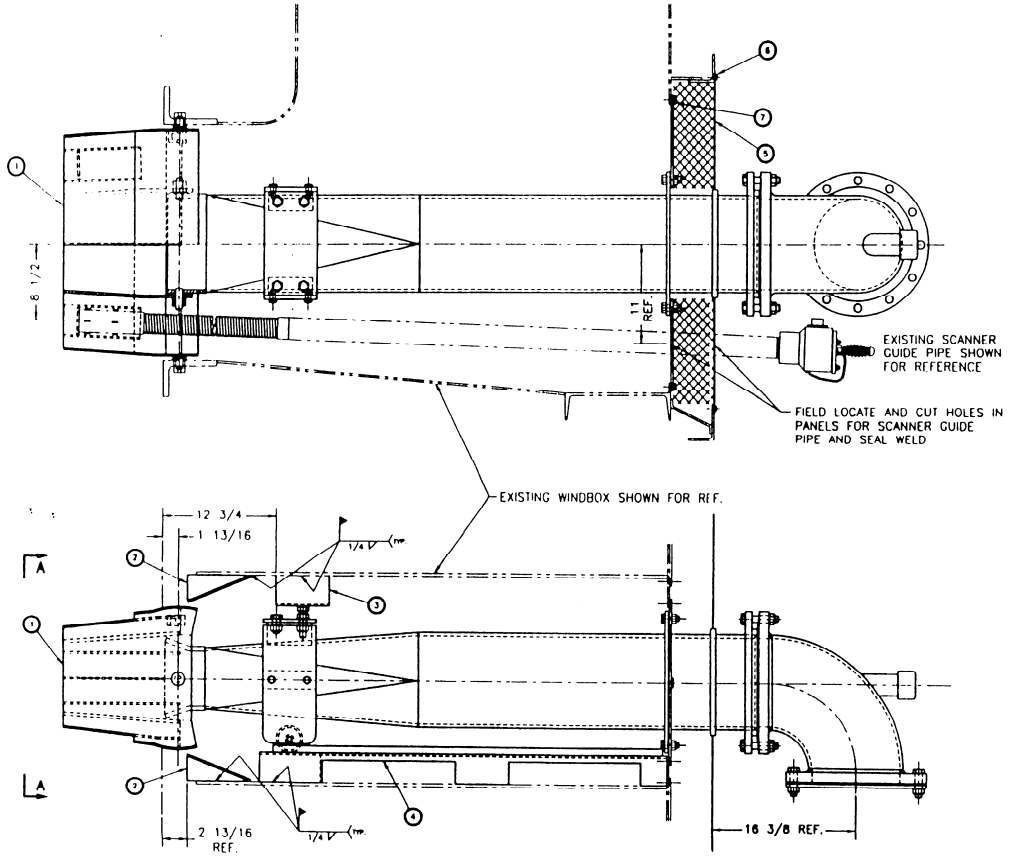
4.1 Key Design Factors

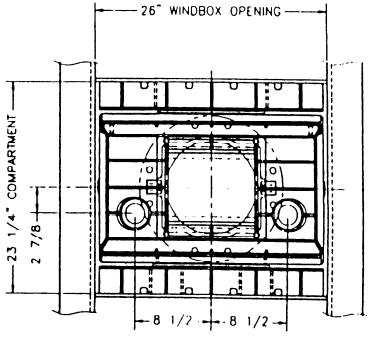
According to the first campaign, the minimum nozzle velocity for the air/switchgrass flow entering the boiler shall be 100 ft/s for the correct injection and to prevent ignition of material still in the transport line. Tests at Studstrup with nozzle velocities of 59 to 65.6 ft/s showed that the lesser share of unburned straw was obtained at the high transport velocity.

4.2 Switchgrass Burner Drawing by Foster Wheeler Engineering

For the engineering drawing on the switchgrass burner, see drawing D-001 on the next page.

1	1	0-86-03022	806603022001	EQUIPMENT ASSEMBLY SWITCH GRASS NOZ	
2	2	0-86-03015	806603015001	AIR DIFLECTOR PLATE	CORTEN
3	1	0-86-03008	806603008001	STATIONARY SUPPORT - UPPER	C/S
4	1	0-86-03006	806603006001	STATIONARY RAIL SUPPORT	C/S
5	1	0-86-03011	806603011001	REMOVABLE FRONT PANEL - OUTER W/ INSUL	C/S
6	18	--	251001032201	HHCS, 3/8"-16 UNC x 1/2" LG	C/S GR 5 ZP
7	26	--	251001033301	HHCS, 1/2"-13 UNC x 3/4" LG	C/S GR 5 ZP





VIEW "A-A"

1	1-21-00	DT	MOVED FLANGE ON BURNER
REV	DATE	BY	DESCRIPTION OF REVISION

FOSTER WHEELER
LOW NOx SYSTEM MODIFICATIONS
SWITCH GRASS NOZZLE ASSEMBLY
26" WINDBOX
23 1/4" COMPARTMENT
IOWA SOUTHERN UTILITIES
OTTUMWA STATION UNIT #1

DRAWING NUMBER	SCALE NTS	
D-001		1
DRAWN BY	dlr	1-20-00
CHECKED BY		
APPROVED BY		

Section 5. Auxiliary Systems

5.1 Compressed Air System

The compressed air system shall provide compressed air for the process controls, for clean up and for maintenance tools. The small compressor shall be placed in the process building on the lower floor level near the MCC room (see drawing 732-3001 in Appendix 1). The compressor will have air lines leading to the four process equipment lines for maintenance and clean-up use and will have one line leading to the process controls area. A small air line to the fire-door area shall be provided at the seal area for clean-up.

5.2 Monorail Systems

One main monorail system shall be located above the debalers for equipment removal (see drawing 732-7002 in Appendix 1). Equipment shall be passed through the mezzanine floor to the lower floor level. Equipment may then be worked on at the lower level or removed through an overhead door in the process building at that location. Welding outlets shall be provided on the lower floor level.

5.3 Building Heat

Steam heaters and associated piping shall be installed for building heat in the process, gallery and storage/receiving buildings. Steam to be provided by Alliant Energy and may be metered. All steam condensate shall be returned to Alliant Energy. The building shall maintain a minimum temperature of 55 degrees Fahrenheit (+10 degrees, -5 degrees). The truck receiving area and other work areas will require localized heat for operator and delivery drivers comfort. Room heaters and air-conditioning shall be provided for the office area and water closet of the processing building (see drawing 732-3001 in Appendix 1). The MCC room shall be equipped with air-conditioning and a vent system.

5.4 Vacuum Cleaning System

Before the trucks leave the unloading area, they must be cleaned for switchgrass waste to prevent switchgrass in the surroundings of the plant. In addition, the vacuum cleaning system is used to clean the buildings of dust and switchgrass waste. The vacuum cleaning system consists of these items:

- Distributed pipe system with a number of connections for hoses making it possible to clean the buildings with hoses not longer than 40 feet;
- PD blower;
- Cyclone and baghouse filter;
- Recycling system. The system transports the collected waste to one of two de-balers
- Container for the collected waste in case cleaning has to be carried out when the plant is out of operation.

Section 6. Control (DCS) and Instrumentation

A computer-based control system (DCS system) is to be supplied and installed for the total switchgrass processing plant with all accompanying auxiliary equipment.

A detailed layout drawing of the proposed control system is to be enclosed to the bid.

The control system is to be designed with two operator stations placed in the power station control room. One of these can also work as engineering station. The operating stations are communicating with substations at the plant. As an option, the bid may include two operator stations located at the switchgrass processing plant.

The substations are established as autonomous process-based units, which – independently of the overall process network and operating station – take care of control, regulation and monitoring of the included switchgrass plant parts.

An engineering station for configuration and programming of the total control system is to be established. Further, the engineering station is to be used for electronic documentation of the total system.

The control system is to comprise a reporting server and a database server. The database server is to collect all relevant data from the process. The supplier is to state the size of the data storage, defined in storage time and number of tags for data.

The supplier is responsible for designing the control system to fulfill the given functional requirements in the best technical and economical way possible, considering the specifications stated in the bid material.

By the design of measuring points the supplier must take into account to make an optimal design under consideration of the location, media, surroundings, etc.

6.1 The Limits of Control

The limits are from the twin conveyor in storage to the valve before the burners, including both items. The control system must be connected to the storage cranes to call for switchgrass when the twin conveyors are empty.

The switchgrass combustion must be integrated in the power station combustion control. The switchgrass energy flow to each of the burners must be measured and controlled.

The changes and signal interface with the existing control system of the power plant are part of the delivery. In other words, the boiler must be able to shutoff the switchgrass flow if there is a boiler trip by means of a digital or analog signal.

6.2 Requirements

In general, the final configured system is to have a reserve capacity for a 30% extension of all functions.

It shall be possible to operate all individual part systems at all automation levels, i.e. the systems are to be controlled in sequences or at the individual controls, like for instance a conveyor.

The screens are to be 21 inches with a minimum resolution of 1024×768, SVGA.

The operating personnel shall have full operational rights to the system.

Admission levels are to be set up regarding the user rights for making changes to the system.

Independently of the chosen control level, the control system is to ensure that – at any time – the operation and running of the plant can take place in a safe and reliable way. This includes the safety of persons, plant and operation. If defects to the production plant or to the control system are stated, the control system is to ensure that the defective plant part is brought to a controlled and secured state.

All analog measurements and set points are to be programmed and registered to be at the operators disposal at operating stations in control rooms and at the database server.

All clocks of the system are to be synchronized from a master clock.

6.3 Automation Degree

It is to be possible to start and stop the system fully automatically from the control room.

This requires:

- The possibility for control and remote control of all part plants and auxiliary plants from the control room.
- Automatic start and stop of auxiliary equipment.

The plant is constructed in a way, which makes it possible to remedy possible system, plant or component defects to the highest possible degree without having to stop the plant.

6.4 Automation Hierarchy

The program structure is hierarchic with the following levels:

- Group level;
- Sequence level;
- Handling of controls/regulation/signals;

Group level is the highest level and control and regulation level the lowest level.

It shall be possible from one level to control the sub-levels from Automatic to Manual and vice versa.

Group Level
At group level the sequence controls or single units, which are functionally belonging together, are connected/disconnected.

Sequence Level
The processing plant can be divided into part processes, which can be controlled by means of sequences.

The sequence control is to give in/out commands to controls and receive reports from the controls in the form of In/Open or Out/Closed respectively and/or from sensors indicating whether, e.g. a desired pressure has been obtained.

Sequence controls are to be with step and criteria indication as well as monitoring and waiting time facilities at each step.

It shall be possible to connect/disconnect the sequence control from a superior automatic and/or from the operating system.

Sequence controls are to be programmed with programming blocks for sequence controls. Sequence controls, where the individual units control each other, are not accepted.

Control Level
All units (valves, motors) are to be programmed with typicals.

The function of the typicals is to:

- start and stop each individual unit;
- protect each individual unit;
- monitor the operation mode of each individual unit.

The typical is to receive start/stop commands, open/close commands and manual/automatic commands from a superior automatic and/or from the operating system.

All protective interlocks are to take place at the control level. Protective interlocks are interlocks for protection of persons and/or to prevent damage to the processing plant.

Handling of Analogous and Binary Signals

The signal level for binary input/output boards for substations is made as 24 V DC. Analog inputs and outputs are made as 4-20 mA. A solution of 10 bits is used as minimum. As a minimum, signals are to be made with an accuracy better than 0.2% of the full scale.

The supplier is to describe how his signal processing has been made in relation to the above, including a statement of how analog signals 4-20 mA are potential-connected to each other and to zero.

6.5 Operating Station

Normally, operating is to take place by means of operating stations, but a small mimic-board with a built-in, fixed wiring, emergency switch is to be included in the supply if the supplier finds it necessary.

The operating stations are to be supplied with full-graphic color screen with keyboard and mouse/track-ball operation. The operation is primarily to take place by use of the mouse/track-ball. All operating stations, engineering stations and report/database servers are each connected to a screen and a keyboard.

The operating stations are working as parallel computers, where all information is available at each of the computers.

Failure to one of the operating stations may not cause failures to the remaining system.

All help programs and other peripheral equipment, which are necessary for troubleshooting at system level and for maintaining the system, are to be included in the supply.

All information at screen pictures and at a possible connected terminal is to be in English and the US alphabetic character set including small and capital letters is to be used at the keyboard and at all operating stations.

The operating stations are to be equipped with a flexible configuration program for the construction of user-defined screen pictures.

Recognizable signatures are to be used for the technical/mechanical plants.

Standardized symbols are to be used for conveyors, measuring points, flow directions etc.

Motors etc. are to change color and form at stop/start, open/closed respectively and to flash in a different color in case of alarm.

Alarm texts are to appear in an eye-catching color. Texts for critical operating functions, critical setting limit values, etc. are to be stated in an eye-catching color.

The Owner is to approve of all symbols, colors, names, designations, abbreviations, etc. The supplier is to make a picture draft for each picture to be approved by the Owner before the picture is constructed.

The presentation is to include defective marking, when the signals are not valid.

From the operating stations it shall be possible to set limits for limit value monitoring and set points and manual/automatic switch for regulators.

As to sequence programs, the presentation is to include display of steps and criteria. When running, it shall be possible to display actual lacking criteria for going to the next step.

6.6 Handling of Alarms

It shall not be possible for an alarm to be lost in the system.

As a minimum, the alarm log is to include:

- Time stamp (solution 10 milliseconds);
- Tag-number and description (minimum 20 characters);
- Status text.

It shall be possible to configure up to five different plant-related alarm lists.

It shall be possible for alarms to accept all modes as combinations of appeared, sent, not acknowledged, acknowledged, alarm manually blocked and alarm automatically blocked, which it shall be possible to identify unambiguously.

It shall be possible to manually block/unblock alarms from the operating stations. Furthermore, it shall be possible to interlock alarms to avoid the appearance of insignificant subsequent alarms.

It shall be possible to define alarms within a total of four prioritized alarm groups and display these with a different color in the alarm list. Each of the prioritized alarm groups is to activate an acoustic horn when activated, which it shall be possible to acknowledge from the keyboard.

It shall be possible to clearly identify the alarm groups on prints printed on black/white printers.

Attention signals are to be established, for instance when required for the crane operator's input to a course.

Further, failures of the control system itself are to be stated in the alarm log.

The alarm log is to be constructed as a cyclic buffer with a capacity of at least 10,000 alarms.

There must be a warning signal and sound in the processing building if equipment is started up from another location, unless the area is controlled with sensors to keep people out of the area.

6.7 Event Log

Events are to be logged with a time stamp (solution 10 milliseconds). An event is to be understood as:

- All changes to the process like for instance start/stop of pumps, opening/closing of valves, etc.;
- Program-specific changes to substations like for instance activation and running of sequence programs, switching of regulators from automatic to manual, etc.;
- Changes initiated by operators;
- Alarms, which are also registered in the alarm log.

The event log is to be designed as a cyclic buffer with a capacity of at least 10,000 events.

It shall be possible to edit/sort in the event log based on time, tag-name, status, group, etc.

6.8 Reports

The report server must be programmed to generate all relevant reports of production and material flow in and out of the plant.

6.9 Configuration

It shall be possible to configure the main station functions; alarm functions, process pictures, operational functions, etc. in an easy way from the engineering station. It shall be possible to make the configuration at the same time as monitoring and operating from the operating stations.

6.10 Performance Requirements for the Operating System

It shall not take more than max. 2 seconds from choosing the operating picture until it appears with an updated picture.

Reaction times for giving commands until receiving reports are to be as follows:

- From pressing a key on the operating station until activation of output at the substation: Max. 1 second.

- From receipt of report from the process at an input at the substation until display at the screen: Max. 1 second.

6.11 Engineering Station

The engineering station is to include backup procedures. Backup is to include all programs as well as a configuration of the control system.

The engineering station is to include tape drives or similar for backup of the system.

Based on the most recent backup media, it shall be possible to re-create the software of the engineering station including all data.

6.12 Communication Net

The transmission speed on the net shall be at least 10 Megabit/sec.

The design of the communication net is to be based on an over-capacity of 100%.

It shall not be possible to loose data during operation.

6.13 Substations

The degree of standardization for the substations is to be high, considering both hardware and software.

The total control system is to be designed with a number of substations, which are to operate independently of each other to ensure that a fault of one substation is limited to this individual substation.

If well-tested and well-documented substations are available for part plants of the machinery, these are to be used to integrate satisfactorily concerning operation, troubleshooting and remedy.

The substation is to start up automatically when re-establishing the supply voltage after a dropout and the system is to adjust to the actual operation mode without giving off commands.

Substations are to be supplied programmed with all functions for control, regulation, monitoring, calculation, data communication, etc.

It shall be possible to expand substations with at least 25% input and output boards for each panel.

6.14 Programming

The program structure is to reflect the structural division of the plant.

The programming of process stations is to be done by means of a PC-based, fully graphical programming tool.

Programming takes place by means of function blocks and macros, drawn by means of a mouse, directly on the fully graphical screen, where function blocks and macros are placed, interconnected and supplied with in- and outputs.

Standard function blocks are to be used.

The programming tool is to be self-documenting, meaning that the drawn programs comply with the actual control and can be printed directly.

Regulators are to be of a kind to enable the choice of manual or automatic operation with a possible external set point.

Switching from manual to auto and reverse is to be a "bumpless transfer".

It shall be possible to choose between the following regulator types: P, PI, PD, PID and times. The individual links may not limit the rest of the links.

All units are to be supplied with running time monitoring.

Standard types are to be clarified in details and agreed upon with the Owner during engineering.

6.15 Input Output (I/O) Signals

For analog input signals: 4-20 mA.

- Solution min. 11 bit + sign.
- Absolute accuracy < ± 0.5%.
- Sample frequency min. 10 Hz.

Analog output signals: 4-20 mA.

- Solution 11 bit + sign.
- Absolute accuracy < ± 0.5%.
- Min load 500 ohm.

Binary (digital) input signals.

- Potential-free switch.
- Working and resting current.
- Output current min. 0.5 A.
- Voltage 24 V DC ± 10%.
- Input current min. 5 mA.

Binary (digital) output signals.

- Fuse with monitoring of each channel.
- Potential-free switch.
- Working and resting current.
- Output current min. 0.1 A.
- Voltage 24 V DC.
- Min. effect at DC 30 W.
- Switching time (incl. flicker) max. 10 ms.

If no conditions speak against it, the above mentioned specifications are valid.

6.16 Panels

Substations are supplied in panels.

The substations are to be placed in a row and with access from the front and the back.

The panels shall have capacity to comprise the scope of supply described in the bid and at the same time to be expanded with at least 25% at all levels after commissioning.

Fixed wired input and output signals are to be connected to the panels by means of master cables.

The panels are to be prepared for building in of ion sensors for fire extinguishing.

Protection degree and corrosive protection are to correspond to the geographical conditions of the location of the panels.

It shall be possible to conduct away the heat building up in the panels without using a ventilator.

6.17 Analog Sensors

The signal level for pressure, differential pressure, temperature, flow, level, setting, etc. is to be 4-20 mA with HART protocol. The maximum load resistance is to be stated.

As far as possible, sensors are to be supplied with voltage via signal wires according to the two-wire principle. Optionally, a field-bus connection can be offered.

The sensor signal is to be galvanically disconnected from earth and steel potentials and possible foreign voltage supply.

It shall be possible to replace the sensors during operation; implying that a shut-off valve with test tap for pressure transmitters, pockets for temperature sensors, etc. shall be installed.

Potentiometer type sensors are not accepted.

The following requirements must be fulfilled:

- Characteristics: Linear
- Load: Zero to approximately 600 Ù.
- Fault limits:
  1. Unlinearity incl. hysteresis and reproducibility: 0.3% of the set measuring area.
  2. Load influence: < 0.05% of max output signal.
  3. Supply voltage influence per 10% change: < 0.01% of max output signal.
  4. Ambient temperature influence per 10°C: At zero point < 0.15% of set measuring area.
  5. Ambient temperature influence per 10°C: At measuring point < 0.3% of set measuring area.
  6. Allowed ambient temperature: -30°C to + 60°C.

It shall be possible to set the damping time of the output signal.

Furthermore, the following applies for the following types:

Pressure transducers
The transducers are to be equipped with a connecting piece for direct installation at a manometer valve. The design of the connecting piece as well as of the valve is to be agreed upon with the Owner.

Differential pressure transducer
The transducers shall be able to withstand a one-sided load with a static nominal pressure at the plus and minus side.

The influence of the static pressure on the zero point is not to exceed:

- PN 1 bar: 0.04% of the max. measuring range for each 0.2 bar.

Temperature sensors
The temperature sensors are to be equipped with double elements, unless otherwise agreed by the Owner.

6.18 Binary (Digital) Sensors

The switches are to be PNP or potential-free switches for 24 V DC. The switch function is to be closed switch for normal operation and open switch for alarm. As an option, a field bus connection can be offered.

Furthermore, the following conditions are to apply:

- It shall be possible to adjust the switching point;
- It shall be possible to adjust the hysteresis 1-2% of full scale;
- Contact manometers etc. are not accepted;
- Centrifugal switches are not accepted;
- Mechanical thermostats are only accepted in special cases;
- Where mechanical switches are used, these shall be micro switches;
- The switches shall be capable of closing a circuit with min. 12 V DC and max. 60 V DC over the open switch;
- The switches are to maintain a safe connection at 2 mA through the closed switch;
- It shall be possible to load the switches with 50 mA;
- The switches are to be supplied with settable activation point and hysteresis;
- Allowed opening/closing frequency is to be 20 switches/min.;
- Lifetime, 2×10^6 switches;
- Repetition accuracy, better than 2% of the activation value.

6.19 Junction Boxes

The Owner supplies junction boxes, etc.

When supplying complete functional units, the following shall apply:

- Any junction box shall be designed for natural cooling (forced cooling will only be accepted under special circumstances).
- As a maximum, 75% of the junction boxes must be utilized.
- To the extent possible, cables shall enter junction boxes from the bottom.

6.20 Video Monitoring

The plant must be erected with a video monitoring system. Following items must be equipped with video cameras:
- Both storage cranes to show the yoke.
- The common conveyors.

- The conveyors until the bales are de-baled.

The cameras must be connected with a matrix to be controlled from the DCS operator stations. One monitor for video monitoring must be in the power station control room and as an option, the bid must offer one at the optional operator station at the switchgrass plant.

All cameras must be able to zoom, horizontally and vertically, controlled from the operator station.

Zoom:	6-30 factor.
Horizontally:	5-350°.
Vertically:	+20, -90°.

Section 7. Electrical Systems

Power distribution from two new transformers shall be provided and installed for the new switchgrass processing plant with storage/receiving facilities. The power source will be from an existing underground feed from existing (13.8 KV) switch located southeast of the existing power plant. The incoming switches for the new transformers will be loop fed. Sizes of the transformers shall be based on the motor list, the anticipated lighting, and branch circuit loads. The transformers primary voltage will be 13.8 KV, one will have a secondary voltage of 2400 V and feed a medium voltage MCC for all motors 200 HP and Larger. The second transformer shall have a 480 V secondary and feed a 480V power distribution center (PDC). The PDC will then be wired to multiple motor control centers (MCC) distributing the power. Cables from the transformer to the secondary switchgear shall be run underground. The MCC feeders and low voltage PDC feeders shall be run overhead via cable tray.

The following page has an anticipated motor list and the associated total HP load for the 25 tph system.

Preliminary Motor List (25 TPH System)

	Per System kW		Per System HP		Total HP	
Crane (2 required)						
Motor hydraulic system	11	kW	15	HP	30	HP
Motor vertical running	(2) x 7.5	kW	(2) x 10	HP	40	HP
Motor hoisting	90	kW	125	HP	250	HP
Twin Bale Conveyors (3 required)						
Motor	7.5	kW	10	HP	30	HP
Transfer Vehicle (1 required)						
Motor sideways transport	1.1	kW	2	HP	2	HP
Motor left bale transport	2.2	kW	3	HP	3	HP
Motor right bale transport	2.2	kW	3	HP	3	HP
Receiving Tables (4 required)						
Motor	4.0	kW	5	HP	20	HP
Buffer Tables (4 required)						
Motor low speed	(1) x 0.95	kW	(1) x 2	HP	8	HP
Motor high speed	(1) x 0.95	kW	(1) x 2	HP	8	HP
De-Twiner System (4 required)						
Motor transport conveyor	0.55	kW	1	HP	4	HP
Motor feeding conveyor	0.55	kW	1	HP	4	HP
Motor twine-cutter	1.1	kW	2	HP	8	HP
Motor twine-remover	3.3	kW	3	HP	12	HP
De-Baler (4 required)						
Motor power pack	(2) x 132	kW	(2) x 200	HP	1600	HP
Incline Conveyor to Hammermill (4 required)						
Motor belt conveyor	3.0	kW	5	HP	20	HP
Motor shredder wheels	(2) x 2.2	kW	(2) x 3	HP	24	HP
Hammermill System (4 required)						
Motor hammer mill	200	kW	250	HP	1000	HP
Motor ID fan	55	kW	75	HP	300	HP
Motor auger	7.5	kW	10	HP	40	HP
Pneumatic Transport System (4 required)						
Motor airlock	5.5	kW	7.5	HP	30	HP
Motor rotary piston blower	75	kW	100	HP	400	HP
Vacuum cleaner (1 required)						
Motor rotary piston blower	30	kW	40	HP	40	HP
Motor, augers and airlock	4.4	kW	7.5	HP	7.5	HP
TOTAL HP Connected:					**3883.5**	**HP**

Appendix 3
Preliminary Design Specifications

Table of Contents for Appendix 3

June 28, 2002

CIVIL AND SITEWORK
TECHNICAL SPECIFICATIONS

For

CHARITON VALLEY BIOMASS PROJECT
FUEL RECEIVING AND PROCESSING FACILITY

at

OTTUMWA GENERATING STATION (Chillicothe, Iowa)

Chariton Valley Resource Conservation and Development, Inc.
Centerville, Iowa

TABLE OF CONTENTS

1 SCOPE OF WORK

1.1 DEMOLITION

1.1.1 Relocated fence line south of the processing building as shown on drawings.

1.2 SITE GRADING

1.2.1 Site grading as required to complete the project on the site. All grades should be held to within an elevation of plus 0 to minus 3 from elevations shown on site work drawings.

2 GENERAL

2.1 The intent of these specifications is to permit the Contractor to propose the procedure and the most economical method to complete the work as outlined in this specification and as shown on the drawing(s).

2.2 Detailed specifications appearing on the drawings or accompanying a purchase order or contract take precedence over these specifications.

2.3 The work shall comply in all respects with the drawings and the specifications and with all laws, ordinances, and regulations or authorities having jurisdiction. In case of conflicting requirements, the most stringent shall govern.

2.4 Should any work be performed in non-compliance with the above, or without a purchase order and approval from the Owner, all costs arising therefrom shall be borne by the company performing the work.

2.5 Changes may be made with the approval of the Owner when such changes become necessary or desirable. Additional payment cannot be authorized unless this has been done, and a written purchase order must be issued before any changes can be made.

2.6 Substitutions shall be by written request only to the Owner, and must be approved by the Engineer.

2.7 All work shall be completed in an adequate, safe, and neat manner, in accordance with environmental regulations, and shall be acceptable to the Owner.

2.8 Owner has a detailed Best Management Practices Plan (BMP) which among other things describes BMP policy, required reporting, and initial response actions resulting from discharge of petroleum products or other hazardous substances. The complete manual is available for review, and the essential applicable sections will be made available at the Contractor's pre-bid walk-through.

2.9 Workmanship shall be of best quality and in accordance with established trade standards.

2.10 The Owner reserves the right to order the removal of any person who, in his opinion, is not qualified or cooperating with other craftsmen in the best interests of the job.

2.11 The Contractor shall provide all equipment and materials, suitable and in adequate quantity, as required to complete the work specified. The Contractor will not be allowed to use any Owner rolling stock or other equipment at any time. All equipment and operators must be supplied by the Contractor.

2.12 All materials provided by the Contractor shall be new and fit for the purpose intended.

2.13 When job is complete, the work area must be left tidy and free of large rock.

2.14 All design work shall be done by a professional engineer registered in the state of the project.

2.15 Any deficiencies identified as part of the original scope of work on the project will be corrected by the Contractor at no additional expense to the Owner.

2.16 Any soil contamination (oil, etc.) to be cleaned per Owner's direction. (Refer to specification 2.8 above.)

3 CLEARING AND GRUBBING

3.1 GENERAL

3.1.1 This section covers clearing and grubbing for the generating station site, coal storage area, substation, railroads, drainage ditches, and roadways.

3.1.2 Overhead utility facilities such as those for telegraph, telephone and power, will be removed or relocated by their owners.

3.1.3 Underground utilities will be removed, relocated, or abandoned in place by their owners. The Contractor will be required to remove only those abandoned underground utilities, or parts thereof, which interfere with the work under these specifications.

3.2 CLEARING AND GRUBBING

3.2.1 Clearing shall include cutting all trees and stumps flush with the original ground surface in each case; the cutting and removal of all brush, shrubs, debris, and all vegetation flush with the ground surface; and the disposal of all cuttings and debris.

3.2.2 Grubbing shall include the removal and disposal of all stumps and roots larger than one inch in diameter, including matted roots regardless of size. Grubbing shall extend to a minimum depth of 12 inches below the natural surrounding ground surface or as otherwise required by the detail specifications.

3.2.3 The Contractor shall not remove or damage trees outside of the areas specified to be cleared or grubbed. The clearing operations shall be conducted without damage to trees which are to be left standing, and without blocking existing roads. Equipment used in clearing and grubbing shall be kept within the specified limits of the work.

3.3 LIMITS OF WORK

3.3.1 The limits of the clearing and grubbing under this section shall include all areas of cut or fill within the limits of construction as indicated on the drawings including but not limited to the following:

A Clearing and grubbing of areas to be occupied by structures.

B Clearing and grubbing of all areas to be occupied by roadway and embankment construction.

C Clearing of the entire road right-of-way.

3.4 DISPOSAL OF WASTE

3.4.1 All logs, trees, stumps, roots, brush, tree trimmings and other materials resulting from clearing and grubbing operations shall become the property of the Contractor and shall be entirely removed from the property or shall be stacked and burned at locations approved by the Field Project Manager. Disposal shall be such that upon completion, the area shall be entirely void of all loose stumps, trimmings, brush, vegetation, and other debris.

3.4.2 All materials to be burned shall be piled and when in suitable condition shall be burned completely. All burning shall be so thorough that the materials are completely reduced to ashes. Piling for burning shall be done in such a manner and in such locations as to cause the least fire risk. Great care shall be taken to prevent the spread of fire. Fire guards of adequate width shall be provided wherever there is surface vegetation around any brush pile, by backfiring or other surface removal or by burying all surface vegetation within fire guard limits. No burning of trimmings or brush shall be done when the direction or velocity of the wind is such that there would be any danger of fire being carried to adjacent areas. Any and all governmental or statutory requirements or regulations relative to fire prevention in general and burning trimmings and brush in particular shall be complied with.

3.4.3 Burn areas shall be a minimum of one-fourth mile away from the nearest inhabitable building as required by state regulations. The use of discarded rubber tires to facilitate burning will not be permitted.

3.4.4 The disposal of noncombustible materials shall be in landfill areas designated by the Field Project Manager.

3.5 EXISTING FENCES

3.5.1 All existing fences within the limits of construction will be removed by the Company.

3.6 EXISTING ROADS

3.6.1 Designated existing roads which are within the Company's property limits may be used as construction roads where indicated on the drawings. All other existing roads within the construction area shall be closed and surfaces broken up and disposed of on the site at a location designated by the Company.

3.6.2 The Contractor shall take note that before any public road is abandoned and closed under these specifications, he shall obtain permission to do so from the authority having jurisdiction.

3.6.3 Bituminous and concrete surfacing materials, culverts and similar existing structures shall be completely removed and disposed of as specified in specification 1.3.4. Earth and aggregate surfaced roads may be worked into the subgrade and graded to match the surrounding contours. All subgrades shall be broken up to a depth of 12 inches, graded, and compacted.

3.6.4 The erection of barricades, warning lights, and other protective devices for road closures shall conform with all regulations of the State of Iowa. The Contractor shall bear all costs and expenses incurred by him in complying with these provisions.

3.7 MISCELLANEOUS UNDERGROUND FACILTIES

3.7.1 All septic tanks and cesspools shall be removed within the limits of the plant site boundary.

3.7.2 Cisterns, storm cellars, and similar structures shall be completely removed and the resulting excavation shall be completely filled to the proper elevation with compacted earth.

3.7.3 Before removing underground fuel tanks, the Contractor shall make certain that all connections are properly closed off and that the tanks are completely purged of all fuel and fumes. It shall also be the Contractor's responsibility to take such other precautionary measures as may be necessary to comply with all governmental regulations regarding such work.

3.8 EXISTING WELLS

3.8.1 All existing wells within the limit of construction shall be sealed. Well sealing shall eliminate physical hazards, prevent the contamination of ground water, conserve the yield and hydrostatic head of aquifers, and prevent the intermingling of desirable and undesirable waters.

3.8.2 Well abandonment shall satisfy all requirements of controlling agencies in the State of Iowa.

4 EARTHWORK

4.1 GENERAL

4.1.1 This section covers general earthwork and shall include the necessary preparation of the construction areas; removal and disposal of all debris; excavation and trenching as required; the handling, storage, transportation, and disposal of all excavated material; all necessary sheeting, shoring, and protection work; preparation of subgrades; pumping and dewatering as necessary or required; protection of adjacent construction; backfilling; pipe embedment; construction of fills and embankments; surfacing and grading; and other appurtenant work.

4.2 SHEETING AND SHORING

4.2.1 The stability of previously constructed structures and facilities shall not be impaired or endangered by excavation work. Previously constructed structures and facilities include both structures and facilities existing when this construction began and structures and facilities already provided under these specifications.

4.2.2 Hazardous and dangerous conditions shall be prevented and the safety of personnel shall be maintained. Adequate sheeting and shoring shall be provided as required to protect and maintain the sides of excavations and trenches until they are backfilled. Sheeting, bracing, and shoring shall be designed and built to withstand all loads that might be cause by earth movement or pressure, and shall be rigid, maintain shape and position under all circumstances.

4.3 REMOVAL OF WATER

4.3.1 The Contractor shall provide and maintain adequate dewatering equipment to remove and dispose of all surface and ground water entering excavations and other parts of the work. Each excavation shall be kept dry during subgrade

preparation and continually thereafter until the construction to be provided therein is completed to the extent that no damage from hydrostatic pressure, flotation, or other cause will result. Ground water level shall be maintained at least 12 inches below the bottom of each excavation.

4.4 BLASTING

4.4.1 No blasting or other use of explosives for excavation will be permitted unless authorized in writing by the Engineer or the Owner.

4.4.2 In the event blasting is authorized, the Contractor shall comply with all laws, ordinances, applicable safety code requirements, and regulations relative to the handling, storage, and use of explosives and the protection of life and property. The Contractor shall be responsible for all damage caused by his blasting operations. Suitable methods shall be employed to confine all materials lifted by blasting within the limits of the excavation and trench.

4.5 CLASSIFICATION OF EARTH MATERIALS

4.5.1 No classification of excavated materials will be made except for identification purposes. Excavation work shall include the removal and subsequent handling of all materials excavated or otherwise removed in performance of the contract work, regardless of the type, character, composition, or condition thereof.

4.5.2 All rock which cannot be handled and compacted as earth shall be kept separate from other excavated materials and shall not be mixed with backfill, fill, or embankment materials except as specified or directed.

4.5.3 Soil identification shall be in accordance with Table 1 of the Unified Soil Classification System. Identification and classification shall be based upon visual examination and simple manual tests performed by qualified personnel furnished by the Contractor.

4.6 FREEZING WEATHER RESTRICTIONS

4.6.1 Backfilling and construction of fills and embankments during freezing weather shall not be done except by permission of the Field Project Manager. No earth material shall be place don frozen surfaces, nor shall frozen materials, snow, or ice be place din any backfill, fill, or embankment.

4.7 MAINTENANCE OF TRAFFIC

4.7.1 The Contractor shall conduct his work so as to interfere as little as possible with the Company's operations and the work of other contractors. Whenever it is necessary to cross, obstruct, or close roads, driveways, parking areas, and walks, the Contractor shall provide and maintain suitable and safe bridges, detours, or other temporary expedients at his own expense. In making open cut road crossings, the Contractor shall not block more than one-half of the road at any time.

4.7.2 Where required by the drawings, the Contractor shall widen the shoulder on the opposite side of the road to facilitate traffic flow while blocking half of a road with an open cut. Temporary crushed rock surfacing shall be provided as necessary on the widened shoulders.

4.8 PRESERVATION OF TREES

4.8.1 Trees shall be preserved and protected as much as possible. Unless specifically authorized by the Company, trees shall be removed from only those areas which will be excavated, filled or built upon. Consideration will be given to the removal of additional trees only where essential, in the opinion of the Field Project Manager, for the safe, effective execution of the work.

4.8.2 Trees left standing shall be adequately protected from permanent damage by construction operations. Trimming standing trees, where required, shall be as directed by the Field Project Manager.

4.9 UNAUTHORIZED EXCAVATION

4.9.1 Except where otherwise authorized, indicated, or specified, all material excavated below the bottom of concrete structures which will be supported by the subgrade shall be replaced with concrete placed monolithic with the concrete above. Material excavated below structures supported on piling or piers shall be replaced with crushed rock or gravel. The crushed rock or gravel shall be compacted to a density equal to or greater than the density of the adjacent undisturbed soil.

4.10 STABILIZATION

4.10.1 Subgrades for structures and the bottom of trenches shall be firm, dense, and thoroughly compacted and consolidated; shall be free from mud and muck; and shall be sufficiently stable to remain firm and intact under the feet of the workmen.

4.10.2 Subgrade for structures and trench bottoms which are otherwise solid but which become mucky on top due to construction operations, shall be reinforced with one or more layers of crushed rock or gravel.

4.10.3 The finished elevation of stabilized structure subgrades shall not be above the subgrade elevations indicated on the drawings.

4.10.4 Not more than 1/2 inch depth of mud or muck shall be allowed to remain on stabilized trench bottoms when the pipe embedment material is placed thereon.

4.10.5 All stabilization work shall be performed by and at the expense of the Contractor.

4.11 TESTING

4.11.1 All field and laboratory testing required to determine compliance with the requirements of this section shall be provided by the Contractor. All laboratory testing shall be done by an independent testing laboratory acceptable to the Engineer and retained and paid by the Contractor. Field sampling shall be done by the testing laboratory or by a qualified employee of the Contractor.

4.11.2 At least one field density determination will be required for each 4000 cubic yards of compacted material. Field samples shall be taken at locations selected by the Field Project Manager. If additional field control tests are necessary, in the opinion of the Field Project Manger, such testes shall be made.

4.11.3 Maximum density for cohesive compacted materials placed under this section shall be determined in accordance with ASTM D698. The terms "maximum density" and "optimum moisture content" shall be as defined in ASTM D1557.

4.11.4 Relative density for noncohesive compacted materials placed under this section shall be determined in accordance with ASTM D2049. the term "relative density" shall be as defined in ASTM D2049.

4.11.5 A copy of each test result shall be promptly furnished to the Company, Engineer, and the Field Project Manager.

4.12 ROADWAY AND RAILROAD ROADBEDS

4.12.1 Roadway and railroad roadbed construction shall include excavation and subgrade preparation, and fills and embankments where required. Fills and embankments shall be constructed as specified hereinafter. In excavated roadbed areas, overburden shall be removed and the subgrade shall be shaped to line, grade and cross section, and compacted to a depth of at least 12 inches to 95 percent of maximum density at optimum moisture content as determined by ASTM D698 when that test is appropriate, or to 70 percent relative density as determined by ASTM D2049 when that test is appropriate. This operation shall include any scarifying, reshaping, and wetting required to obtain proper compaction. Soft, organic, and otherwise unsuitable material shall be removed from the subgrade and replaced with suitable material.

4.12.2 All material in the upper 18 inches of the subgrade in both cut and fill sections, shall be material with compaction characteristics equal to or better than inorganic clays of low to medium plasticity. This material shall be classified as Group CL or ML as indicated on the Unified Soil Classification chart.

4.12.3 The subgrade shall be compacted and finished to a true surface and no depression shall be left that will hold water or prevent proper drainage. The subgrade shall be finished to within 0.1 of a foot of the elevation indicated on the drawings. Any deviation of the subgrade surface in excess of one inch as indicated by a 16 foot straightedge, or template cut to typical section, shall be corrected by loosening, adding or removing material, reshaping, and recompacting.

4.12.4 Ditches and drains along the subgrade shall be maintained as required for effective drainage. Whenever ruts of 2 inches or more in depth are formed, the subgrade shall be brought to grade, reshaped, and recompacted. Storage or stockpiling of material son the subgrade will not be permitted.

4.12.5 Roadway subgrades shall be maintained throughout the work under these specifications. Roadway surfacing is covered in section 5.

4.12.6 Railroad subgrades shall be maintained throughout the work under these specifications. Trackwork will be performed under separate specifications.

4.12.7 Moisture content shall be optimum to plus 2 percent.

4.13 FILLS AND EMBANKMENTS

4.13.1 To the maximum extent available, suitable earth materials obtained from excavation shall be used for the construction of fills and embankments. Additional material shall be obtained from borrow pits as necessary. After preparation of the fill or embankment site, the subgrade shall be scarified, leveled, and rolled so that surface materials of the subgrade will be compact and well bonded with the first layer of the fill or embankment. All material deposited in fills and embankments shall be free from rocks or stones, brush, stumps, logs, roots, debris and organic or other objectionable materials. Fills and

embankments shall be constructed in horizontal layers not exceeding 8 inches in uncompacted thickness. Material deposited in piles or windrows by excavating and hauling equipment shall be spread and leveled prior to compaction.

4.13.2 Each layer shall be thoroughly compacted by rolling or other methods acceptable to the Engineer. The compacted density of each layer shall be at least 95 percent of the maximum density at optimum moisture content as determined by ASTM D698 when that test is appropriate or 70 percent of relative density as determined by ASTM D2049 when that test is appropriate. If the material fails to meet the density specified, compaction methods shall be modified as required to attain the specified density.

4.13.3 Subgrade Preparation. After preparation of the fill or embankment, the subgrade shall be leveled and rolled so surface materials of the subgrade will be as compact and well bonded with the first layer of the fill or embankment as specified for subsequent layers.

4.13.4 Placement and Compaction. All fill and embankment materials shall be placed in approximately horizontal layers not to exceed 8 inches in uncompacted thickness. Material deposited in piles or windrows by excavating and hauling equipment shall be spread and leveled before compaction. Moisture content shall be optimum to plus 2 percent.

A Each layer of material being compacted shall have the best practicable uniform moisture content to insure satisfactory compaction. The Contractor shall add water and harrow, disc, blade, or otherwise work the material in each layer as required to insure uniform moisture content and adequate compaction. Each layer shall be thoroughly compacted by rolling or other acceptable methods to 95 percent of maximum density at optimum moisture content unless otherwise specified. If the material fails to meet the density specified, compaction methods shall be altered.

4.13.5 Borrow Areas. Material necessary to complete fills and embankments shall be excavated from borrow areas and hauled to the fill or embankment site. Borrow material will be available on the Company's property.

B The location, size, shape, depth, drainage, and surfacing of all borrow areas shall be acceptable to the Field Project Manager. Borrow areas shall be regular in shape, with finish graded surfaces when completed. Side slopes shall not be steeper than three horizontal to one vertical, and shall be uniform for the entire length of any one side.

4.14 STRUCTURE EXCAVATION

4.14.1 Excavation for structures shall be done to lines and elevations indicated on the drawings and to the limits required to perform the construction work. Machine excavation shall be controlled to prevent undercutting the proper subgrade elevations.

4.14.2 Work shall be done so that the construction areas will be as free as possible from obstructions and from interference with the transportation, storage, or handling of materials. Excavated materials free of trash, rocks, roots, and other foreign materials, and which meet the specified requirements, may be used as required for the fills, embankments, and backfills constructed under these specifications.

4.14.3 Vertical faces of excavations shall not be undercut to provide for extended footings.

4.15 STRUCTURE BACKFILL

4.15.1 Backfill around and outside of structures shall be deposited in layers not to exceed 6 inches in uncompacted thickness and mechanically compacted, using platform type tampers, to at least 90 percent of maximum density at optimum moisture content as determined by ASTM D698 when that test is appropriate, or to 70 percent relative density as determined by ASTM D2049 when that test is appropriate. Compaction of structure backfill by rolling will be permitted provided the desired compaction is obtained and damage to the structure is prevented. Compaction of structure backfill by inundation with water will not be permitted.

4.15.2 Material for structure backfill shall be composed of earth only and shall contain no wood, grass, roots, broken concrete, stones, trash, or debris of any kind.

4.15.3 No tamped, rolled, or otherwise mechanically compacted backfill shall be deposited or compacted in water.

4.15.4 All backfill material shall consist of loose earth having a moisture content such that the required density of the compacted soil will be obtained with the compaction method used. Moisture content shall be distributed uniformly and water for correction of moisture content shall be added sufficiently in advance so that proper moisture distribution and compaction will be obtained. Granular material shall be wet, not just damp, when compacted.

4.15.5 Particular care shall be taken to compact structure backfill which will be beneath pipes, drives, roads, or other surface construction or structures. In addition, wherever a trench will pass through structure backfill, the structure backfill shall be placed and compacted to an elevation at lest 12 inches above the top of the pipe before the trench is excavated.

4.16 DRAINAGE FILLS

4.16.1 Drainage fills shall consist of granular materials of the type indicated on the drawings. Sand shall be clean sand uniformly graded from No. 4 to No. 100 sizes. Drainage filter material shall consist of washed crushed rock or gravel uniformly graded from 1-1/2 inch to No. 4.

4.16.2 Sand drainage fill shall be compacted with a vibrating compactor. Moisture content of the sand shall be adjusted to achieve maximum density.

4.16.3 Drainage filter material shall be placed to the approximate limits indicated and shall be compacted to a degree which will permit water to pass through it readily but will not have excessive settlement later.

4.17 MAINTENANCE AND RESTORATION OF FILLS, EMBANKMENTS, AND BACKFILLS

4.17.1 Fills, embankments and backfills that settle or erode before final acceptance of the work under these specifications, and pavement, structures, and other facilities damaged by such settlement or erosion, shall be repaired. The settled or eroded areas shall be refilled, compacted, and graded to conform to the elevation indicated on the drawings or to the elevation of the adjacent ground surface. Damaged facilities shall be repaired in a manner acceptable to the Field Project Manager.

4.17.2 Earth slopes of the roads and railroad bed constructed under these specifications shall be maintained to the lines and grades indicated on the drawings until the final acceptance of the road slopes by the authorities having jurisdiction.

4.18 FINAL GRADING

4.18.1 After all construction work under these specification has been completed, all ground surface areas disturbed by this construction or construction plant and operations shall be graded. The grading shall be finished to the contours and elevations indicated on the drawings or, if not indicted, to the matching contours and elevations of the original, undisturbed ground surface. In any event, the final grading shall provide smooth uniform surfacing and effective drainage of the ground areas.

4.19 ARCHAEOLOGICAL SALVAGE

4.19.1 Whenever the Contractor's operations encounter remains of historic people's dwelling sites or artifacts of historical or archaeological significance, the operations shall be temporarily discontinued at the site. The Field Project Manager will contact the proper archaeological authorities of the State of Iowa who shall determine the disposition thereof.

4.19.2 When so directed by the Field Project Manager, the Contractor shall excavate the site in such a manner as to preserve the artifacts encountered and remove them for delivery to the custody of proper state authorities.

5 CRUSHED ROCK SURFACING

5.1 GENERAL

5.1.1 This section covers the materials and construction for access roads and the construction parking area.

5.1.2 Major earthwork for the access roads and construction parking area shall be as specified under section 4. Roadbeds for access roads shall be as specified in article 4.12 Roadway and Railroad Roadbeds.

5.1.3 All crushed rock surfaced roads and parking areas shall be maintained by the Contractor until fianl acceptance of the work under these specifications

5.1.4 Unless otherwise specified, the workmanship and materials shall be as specified herinafter or shall conform to Section 2208 (excluding bitumen primer) and 2312 of the Standard Specifications for Construction on Primary Farm to Market, Secondary, State Park, and Institutional Roads and Maintenance Work on the Primary Road System, Series of 1972, Iowa State Highway Commission, Ames, Iowa, herinafter referred to as Standard specifications.

5.2 MATERIALS

5.2.1 Materials for the crushed rock surfacing and base course shall conform to the following requirements:

Base course for all surfacing	Section 4120.07 of the Standard Specifications, Class D crushed stone; max particle Size 1-1/2 inch, percent passing No. 8 sieve 20 to 35 percent, amx allowable mud ball content 5 percent.
Surface course for all surfacing	Section 4120.04 of the Standard Specifications, Class A crushed stone.

5.3 APPLICATION

5.3.1 The crushed rock for construction of surfacing shall be applied in uniform layers not to exceed 4 inches in compacted depth. Total compacted depth shall be in accordance with the following:

Surfacing Type	Compacted Depth (inches)	
	Base Course	Surface Course
I, II	6	2
III	4	2

5.3.2 The crushed rock for each course shall be handled and spread in a manner that will prevent segregation of sizes. Each layer shall be carefully and uniformly spread, and when sufficiently deep to form a compacted layer of the specified thickness it shall be rolled by at least four passes of a road type vibrator compactor or pneumatic tired roller.

5.3.3 The completed surfaces shall be free of ruts, depression, and other suface disturbances and shall be finished to the lines and grades indicated on the drawings.

5.4 MAINTENANCE OF SURFACING

5.4.2 Maintenance of the crushed rock surfacing shall consist of daily inspection and periodic maintenance operations by the Contractor throughout the period utilized to complete the work under these specifications. Maintenance operations shall include looseing, adding, and removing material, grading, reshaping, and recompacting as required to keep the crushed rock surfaced areas in good condition.

~~5.4.2~~5.4.3 Maintenance and resufacing of the new surfaced areas shall be provided as directed by the Field Project Manager.

5.5 DUST CONTROL

5.5.2 The Contractor shall provide all dust control related to the use of crushed rock surfaced roads and parking areas. When directed by the Field Project Manager, the Contractor shall apply moisture to the roads and parking areas as necessary to prevent the spread of dust. Calcium chloride shall be used to stabilize crushed rock surfacing. Calcium chloride shall be added in either dry or liquid form at the Contractor's option. The amount of calcium chloride sued in the base course shall be from 7 to 10 pounds of Type 1 or 5.6 to 8 pounds of Type 2 per ton of aggregate. The amount used in the surface course shall be 2 pounds of Type 1 or 1.6 pounds of Type 2 calcium chloride per square yard. Where a range of calcium chloride is specified, the larger amount shall be used in the hot and dry summer weather. Calcium chloride stabilization shall be in accordance with

"Materials for Stabilization" as published by the "American Road Builders Association" (HC-100 Oct. 1971).

6 CEMENT CONCRETE PAVEMENT

6.1 GENERAL

6.1.1 This Section includes cement concrete pavement for the following applications:

A Driveways and roadways.

B Parking lots.

C Curbs and gutters.

D Walkways.

6.2 SUBMITTALS

6.2.1 Design Section: For each area indicated.

6.2.2 Product Data: For each manufactured material and product indicated.

6.2.3 Design Mixes: For each concrete mix indicated.

6.2.4 Material certificates: Signed by manufacturers certifying that each concrete material complies with requirements.

6.3 QUALITY ASSURANCE

6.3.1 Comply with ACI 301, "Specification for Structural Concrete," unless modified by the requirements of the Contract Documents.

A Installer Qualifications: An experienced installer who has completed pavement work similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.

B Manufacturer Qualifications: Manufacturer of ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.

6.4 FORM MATERIALS

6.4.1 Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, smooth exposed surfaces.

6.5 STEEL REINFORCEMENT

6.5.1 Plain-Steel Welded Wire Fabric: ASTM A 185, flat sheets.

6.5.2 Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed.

6.5.3 Plain Steel Wire: ASTM A 82, as drawn.

6.5.4 Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening steel reinforcement. Manufactured according to CRSI's "Manual of Standard Practice"

6.6 Concrete Materials

6.6.1 Portland Cement: ASTM C 150, Type I or II.

A Fly Ash: ASTM C 618, Class F or C.

B Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.

6.6.2 Aggregate: ASTM C 33, uniformly graded, from a single source.

6.6.3 Water: ASTM C 94.

6.6.4 Admixtures certified by manufacturer to contain not more than 0.1 percent water-soluble chloride ions by mass of cement and to be compatible with other admixtures, as follows:

A Air-Entraining Admixture: ASTM C 260.

B Water-Reducing Admixture: ASTM C 494, Type A.

C High-Range, Water-Reducing Admixture: ASTM C 494, Type F.

D Water-Reducing and Accelerating Admixture: ASTM C 494, Type E.

E Water-Reducing and Retarding Admixture: ASTM C 494, Type D.

6.6.5 Curing Materials:

A Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. dry.

B Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

C Water: Potable.

D Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.

E Clear Solvent-Borne Liquid-Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B.

F Clear Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B.

6.6.6 Related Materials:

A Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber, or ASTM D 1752, cork or self-expanding cork.

6.7 CONCRETE MIXES AND MIXING

6.7.1 Concrete Mixes: Prepare design mixes, proportioned according to ACI 211.1 and ACI 301, with the following properties:

A Compressive Strength (28 Days): 3500 psi.

B Maximum Water-Cementitious Materials Ratio: 0.50.

C Slump Limit: 4 inches.

D Air Content: 4.5 to 7.5 percent.

6.7.2 Ready-Mixed Concrete: Comply with requirements and with ASTM C 94.

6.7.3 Project-Site Mixing: Comply with requirements and measure, batch, and mix concrete materials and concrete according to ASTM C 94. Mix concrete materials in appropriate drum-type batch machine mixer.

6.8 INSTALLATION

6.8.1 Surface Preparation: Proof-roll prepared subbase, and remove loose material from surface.

6.8.2 Forms: Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for pavement to required lines, grades, and elevations.

6.8.3 Reinforcement: Accurately position and support reinforcement, and secure against displacement. Set wire ties with ends directed into concrete.

A Install welded wire fabric in lengths as long as practicable; lap at least one full mesh, and lace splices with wire.

6.8.4 Joints: Locate and install construction, isolation, contraction, and expansion joints as indicated.

6.8.5 Concrete Placement: Comply with recommendations in ACI 304R for measuring, mixing, transporting, and placing concrete. Place concrete in a continuous operation within planned joints or sections.

A Moisten subbase to provide a uniform dampened condition at time concrete is placed.

B Consolidate concrete by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping according to recommendations in ACI 309R.

C Screed and initial-float concrete surfaces with darby or bull float before excess moisture or bleed water appears on the surface.

D Protect concrete from cold or hot weather during mixing, placing, and curing.

6.8.6 Evaporation Retarder: Apply to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

6.9 FINISHES AND CURING

6.9.1 Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and the concrete surface has stiffened sufficiently to permit operations. Float surfaces to true planes with gaps below 10-foot- long, unleveled straightedge not to exceed 1/4 inch. Cut down high spots, and fill low spots. Refloat surface immediately to uniform granular texture.

A Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.

B Medium-to-Fine-Textured Broom Finish: Draw a soft bristle broom across float-finished concrete surface, perpendicular to line of traffic, to provide a uniform, fine-line texture.

C Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch deep with a stiff-bristled broom, perpendicular to line of traffic.

6.9.2 Curing: Begin curing after finishing concrete, but not before free water has disappeared from concrete surface. Cure concrete by one or a combination of the following methods:

A Moisture cure concrete by water, continuous fog spray, continuously wet absorptive cover, or by moisture-retaining-cover curing. Keep surfaces continuously moist for not less than seven days.

B Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

6.10 REPAIRS AND PROTECTION

6.10.1 Remove and replace concrete pavement that is broken, damaged, or defective, or does not meet requirements in this Section.

6.10.2 Protect concrete from damage. Exclude traffic from pavement for at least 14 days after placement.

6.10.3 Maintain concrete pavement free of stains, discoloration, dirt, and other foreign material. Sweep concrete pavement not more than two days before date scheduled for Substantial Completion inspections.

7 DISPOSAL OF MATERIALS

7.1 All scrap and organic laden materials, including materials resulting from demolition that is not suitable for structural fill must be removed from the plant site and properly disposed of at Contractor’s expense. All building materials that have been painted with lead base paint or that contain asbestos materials are to be identified by the Contractor and will require special disposal methods as directed by the Owner, and will be disposed by the Owner.

7.2 Clean fill material and gravel may stay on the plant site and will not have to be removed to landfill, but must be deposited on the site in a location specified by the Owner.

7.3 Asphalt may stay on the plant site, kept separated, broken into fill that is 6-inch minus (with adequate gradation to allow thorough compaction), and deposited on-site in a specific location as specified by the Owner.

7.4 Prior to filling any area, all organic laden soils must be removed and any soft deposit areas must be compacted.

8 FIRE WATCH

8.1 In all cases, Contractor is to adhere to Alliant Energy's burning & welding permit process to ensure that the plant security personnel are aware of all burning & welding that has occurred during the day.

8.2 In addition, Contractor must adequately wet down all affected areas prior-to and after burning or welding.

8.3 Contractor to supply a fire watch for at a minimum of one (1) hour after any cutting or welding has taken place.

June 28, 2002

CONCRETE INSTALLATION
TECHNICAL SPECIFICATIONS

For

CHARITON VALLEY BIOMASS PROJECT
FUEL RECEIVING AND PROCESSING FACILITY

at

OTTUMWA GENERATING STATION (Chillicothe, Iowa)

Chariton Valley Resource Conservation and Development, Inc.
Centerville, Iowa

TABLE OF CONTENTS

1 SCOPE OF WORK

1.1 Supply all building and equipment foundations, as well as all concrete slabs as required to complete the project as shown on drawings and as described in the project documents.

1.2 Supply concrete under pipe bridge and under gallery support bents.

2 GENERAL

2.1 All materials provided by the Contractor shall be new and fit for the purpose intended.

2.2 Detailed specifications appearing on the drawings or accompanying a purchase order or contract take precedence over these specifications.

2.3 Workmanship shall be of best quality and in accordance with established trade standards.

2.4 All details of construction and materials shown or as described by the drawings or specifications, which are subject to question, shall be brought to the attention of the Engineer or Owner in writing by the Contractor before the contract has been awarded. If no questions have been raised as above-stated, no allowance will be made for any misunderstanding.

2.5 The work shall comply in all respects with the drawings and the specifications and with all laws, ordinances, and regulations or authorities having jurisdiction. In case of conflicting requirements, the most stringent shall govern.

2.6 Should any work be performed in non-compliance with the above, or without a purchase order and approval from the Owner, all costs arising therefrom shall be borne by the company performing the work.

2.7 Changes may be made with the approval of the Owner when such changes become necessary or desirable. Additional payment cannot be authorized unless this has been done, and a written purchase order must be issued before any changes can be made.

2.8 The Contractor shall provide all equipment and materials, suitable and in adequate quantity, as required to complete the work specified. The Contractor will not be allowed to use any Owner rolling stock or other equipment at any time. All equipment and operators must be supplied by the Contractor.

2.9 When the job is completed, the work area must be left broom-clean.

2.10 All work shall be executed in a workman-like manner, and shall present a neat and mechanical appearance upon completion. The Contractor shall provide and apply touch-up paint to all equipment as necessary.

2.11 The Engineer and Owner reserve the right to order the removal of any person who, in his opinion, is not qualified or cooperating with other craftsmen in the best interests of the job.

3 SITE PREPARATION

3.1 Rough grading to be done under the Civil and Sitework section of these specifications.

3.2 Contractor to place a minimum 6" thick layer of 3/4" minus crushed rock under slab areas, compacted to 90% ASTM D 1557.

3.3 Backfill material shall be 1-1/2”-minus crushed rock placed in uniform horizontal layers not to exceed 8" in loose thickness depth. Each layer shall be completed, leveled and thoroughly compacted to 95% modified proctor density, ASTM D 1557, before the succeeding layer is placed.

3.4 Utility trench backfill above pipe bedding material shall be in accordance with specification 3.3, above.

3.5 SLABS-ON-GRADE: Soils must be compacted to a minimum density of 90% of ASTM D 1557. This includes proof-rolling in-place soils, soils that have been disturbed during construction, and all structural fill materials.

3.6 No fill is to be placed during periods of unfavorable weather or while the fill is frozen or thawing. When work is stopped by rain, placement of fill will not resume until the soils engineer or engineering geologist determines that the moisture content is suitable for compactive effort and that the previously-placed fill has not been loosened. The Contractor will take appropriate measures during unfavorable weather to protect the fill already placed. Measures that may be required include limiting wheeled traffic and grading to provide temporary drainage of the fill. At the direction of the soils engineer or engineering geologist, the Contractor will be responsible for the removal and re-working of fill that has softened or has less than the required compaction.

3.7 Foundation design shall be, at minimum, in accordance with the geotechnical report.

4 CONCRETE SLABS AND FOUNDATIONS

4.1 GENERAL

4.1.1 All concrete work shall be done in accordance with the latest edition of the ACI Building Code (ACI 318-89) and the latest editions of the ACI Manuals of Concrete Practice.

4.1.2 This division of work includes all labor, materials and services necessary for, and reasonably incidental to, the completion of all concrete work as included in the scope of work as outlined in these specifications.

4.2 EXCAVATION

4.2.1 All footings shall be founded a minimum of 18" into firm undisturbed or well-compacted soil with allowance for a minimum 6" depth of 1/2"-minus crushed rock.

4.2.2 Dimensions shown to bottom of footings are a minimum, but may change per specification 4.2.1, above.

4.2.3 Foundation thicknesses indicated are minimums.

4.2.4 The last 3" of soil shall be removed by hand-tool operation to neat lines.

4.2.5 No excavation shall be made below any existing footing which is closer than 1 foot vertical to 2 feet horizontal.

4.2.6 It is the responsibility of the Contractor to place all waste and debris, during excavation, at assigned location on the Owner’s property. Owner will dispose of materials.

4.3 CONCRETE

4.3.1 Concrete Strength: Standard for footings and slabs on grade; 3000 psi @ 28 days.

4.3.2 Concrete Consistency / Slump Requirements: Slab and walls 4" slump; Footings 3" maximum slump.

4.3.3 Maximum Aggregate Size: 1" for slabs and walls, 1-1/2" for typical footings, and 2" for 36”-deep mass footings.

4.3.4 Maximum Water/Cement Ratios: 0.59 or as required by the approved mix design, whichever is lower.

4.3.5 Cement Content: 5 sacks/cubic yard.

4.3.6 Admixtures (Allowed):

A Pozzolith 300-N at 5 oz. per cement sack, or Zeecon R at 4 (±1) fluid oz. per cement sack.

B M.B.V.R., MB-AE10, or Darex of strength required to provide between 3-1/2% and 5% of entrained air.

C Concrete Curing: Keep concrete continuously wet for 7 days, or use a spray-on curing compound.

4.3.7 Vibration: Vibrate all concrete in place with a mechanical vibrator used by experienced personnel (including full depth of piles and caissons).

4.3.8 Testing:

A The Contractor shall take one set of 3 test-cylinders for each 50 yards of concrete and/or each day's pour.

B These cylinder shall be taken to an approved laboratory and tested: 1 cylinder at 7 days, and 2 cylinders at 28 days, for each set. The results shall be submitted to the Owner's representative. All costs of the test are included in the contract amount.

C Concrete failing to meet above specifications for slump and/or strength may be rejected or condemned and ordered removed by the Owner at the expense of the Contractor and without recourse to the Owner.

4.3.9 Concreting method, reinforcing, forms and shores shall conform to requirements as set forth by ACI 318-83, latest edition standard.

4.4 SLABS

4.4.1 On all exterior concrete slabs, provide 1/2" expansion joints at 40'-0" on-center each way. On all slabs, provide control joints at 20'-0" on-center each way. (Unless specified otherwise on drawings.)

4.4.2 Slab thickness and reinforcing shall be designed and installed as required for the applied loads.

4.4.3 Finish for interior slabs to be float and light broom finish in work area; power-trowel for remainder.

4.4.4 All exposed corners to have 3/4”x45° chamfer, unless specified otherwise on drawings.

4.5 REINFORCING STEEL

4.5.1 All reinforcing steel shall conform to current ASTM specification A615 deformed bars with a minimum yield of 60,000psi. All ties and hooks may be 40,000psi.

4.5.2 All welded-wire fabric shall conform to current ASTM specifications.

4.5.3 All reinforcing steel shall be detailed, fabricated, and placed in accordance with current ACI Detailing Manual, unless shown otherwise.

4.5.4 All hooks and bends shall conform to ACI standards, unless otherwise shown.

4.5.5 All reinforcing steel shall be accurately and securely placed.

4.5.6 Reinforcing steel shall not be bent or displaced for the convenience of other trades.

4.5.7 Unless detailed in the specifications, concrete cover shall be 3" bottom of footings, 2" to face of walls on backfill side, 1-1/2" to interior face of walls, 2" in beams and columns to main reinforcing, 1" in joists and 3/4" in slabs, unless otherwise shown on the drawings.

4.5.8 Minimum lap shall be per current UBC requirements.

4.5.9 Conduit in slabs shall be placed between top and bottom slab steel.

4.5.10 All openings in slabs for pipes 3" in diameter or greater, shall be sleeved with standard steel pipe 1" larger in diameter than pipe, with four #4 x 1'-6" welded anchors.

4.5.11 Outside diameter of conduits or pipe embedded in slab shall not exceed 30% of slab thickness or 13", whichever is smaller, unless specifically detailed otherwise. All conduits or pipes larger than the 13" (O.D.) or 30% of slab thickness, shall be placed under the slab. Conduits can be routed in pairs. Minimum clear distance between single conduits or pairs shall be 6".

4.6 WELD PADS & EMBEDS

4.6.1 The Erector shall maintain all base lines and provide all other lines and levels as may be necessary for execution of the work.

4.6.2 All weld pads must be level within ±1/8" in 12" and be set at " 1/8" of indicated elevations.

4.6.3 Pads should be minimum of flush, to 1/8" maximum above the level of concrete.

4.6.4 Anchor bolts to be placed within ±1/8" horizontal location, and within 1/8" in 12" vertical.

4.6.5 Welded connections shall be fitted-up and welded in conformance with the latest American Welding Society code for fusion welding. Welding shall be done by AWS-certified welders. Only qualified welders may perform the welding operations.

4.6.6 Structural steel and plates shall conform to ASTM specifications A36 unless otherwise noted on the drawings.

5 FIRE WATCH

5.1 In all cases, Contractor is to adhere to Alliant Energy's burning & welding permit process to ensure that the plant security personnel are aware of all burning & welding that has occurred during the day.

5.2 In addition, Contractor must adequately wet down all affected areas prior-to and after burning or welding.

5.3 Contractor to supply a fire watch for at a minimum of one (1) hour after any cutting or welding has taken place.

June 28, 2002

BUILDING INSTALLATION
TECHNICAL SPECIFICATIONS

For

CHARITON VALLEY BIOMASS PROJECT
FUEL RECEIVING AND PROCESSING FACILITY

at

OTTUMWA GENERATING STATION (Chillicothe, Iowa)

Chariton Valley Resource Conservation and Development, Inc.
Centerville, Iowa

TABLE OF CONTENTS

1 SCOPE OF WORK

1.1 Supply and install all building components for both the storage building and the processing building as shown on the drawings and as described by project documents.

1.2 Supply supports for crane rails in the storage building as integral parts of the building structure as shown on drawings.

1.3 Supply and install steam heaters and associated piping for the complete installation. Steam supply is provided by Alliant Energy. Temperature in building to be designed to be no lower than 55 degree Fahrenheit (+10 degrees, -5 degrees). The truck receiving area and other work areas may require localized heat for operator comfort.

1.4 Provide and install room heat and air conditioning for the office area and water closet of the processing building.

2 GENERAL

2.1 The intent of these specifications is to permit the Contractor to propose the materials and design which will provide the most economical system within the limitations outlined in this specification and as shown on the drawing(s).

2.2 Detailed specifications appearing on the Program and Performance Criteria drawings or accompanying a purchase order or contract take precedence over these specifications.

2.3 The work shall comply in all respects with the Program and Performance Criteria drawings and the specifications and with all laws, ordinances, and regulations or authorities having jurisdiction. In case of conflicting requirements, the most stringent shall govern.

2.4 Should any work be performed in non-compliance with the above, or without a purchase order and approval from the Owner, all costs arising therefrom shall be borne by the company performing the work.

2.5 Substitutions shall be by written request only to the Owner or Owner's representative.

2.6 All work shall be completed in an adequate, safe, and neat manner, and shall be acceptable to the Owner or Owner's representative.

2.7 Workmanship shall be of best quality and in accordance with established trade standards.

2.8 All work shall be executed in a workman-like manner, and shall present a neat and mechanical appearance upon completion. The Contractor shall provide and apply touch-up paint to all equipment as necessary.

2.9 All materials provided by the Contractor shall be new and fit for the purpose intended.

2.10 When job is complete, the work area must be left broom-clean.

2.11 All design work shall be done by a professional engineer registered in the state of the project.

3 BUILDING INSTALLATION

3.1 This division of work includes all labor, materials and services necessary for, and reasonably incidental to, the installation of steel building(s) as outlined in the scope of work of these specifications.

3.2 The intent of these specifications is to permit the Contractor to propose the materials and design which will provide the most economical system within the limitations outlined in this specification and as shown on the drawing(s).

3.3 Detailed specifications appearing on the drawings or accompanying a purchase order or contract take precedence over these standards.

3.4 The building shall be of the size and configuration as shown on the drawings.

3.5 The work includes design, fabrication, supply, delivery, and erection of the specified building, complete at the Owner's plant site.

3.6 All design work shall be done by a registered professional engineer licensed in the state where the building will be erected.

3.7 The building envelope shall comply with all Iowa state requirements with regard to insulation, glazing, and doors, moisture control, and air leakage control.

3.8 The building design, materials, and installation shall be in accordance with all current applicable code regulations and insurance requirements, including the following:

- State of Iowa Building Code (IAC Chapters 5 and 16) including Divisions VII, Accessiblity Rules and Divison VIII, Energy Conservation.
- 1994 Uniform Building Code, as amended by the State of Iowa.
- Article 81 of the 1994 Uniform Fire Code for high piled storage
- Federal Occupational Safety and Health Administration Standards.
- Metal Building Manufacturers Association (MBMA) Low Rise Building Systems Manual.
- American Concrete Institute (ACI) 301, 318.
- American Institute of Steel Construction (AISC) ASD Ninth Ed. or LRFD 3rd Ed.
- American Iron and Steel Institute (AISI) Specification for the Design of Cold Formed Steel Structural Members.
- American Welding Society.
- Steel Door Institute.
- Factory Mutual Insurance Co. requirements.

3.9 Frame spans and spacing are shown on the drawings.

3.10 The Contractor's proposal shall define any necessary provision for thermal expansion of the roof and wall systems.

3.11 The building structure shall be designed and constructed to carry minimum loads in accordance with all applicable code regulations including:

3.11.1 Dead load shall include the actual building dead-load plus an additional 5 PSF applied to the bottom of roof support members to allow for sprinkler systems, electrical systems, and plumbing. Collateral load equals 3 psf minimum at storage building, 8 psf minimum at the process building. Support sprinkler mains as required.

3.11.2 Storage building is to include structural components for rail beams (2) for a 20-ton bridge crane. Crane loads: Tonnage specified on drawings. Design for 25 percent minimum vertical impact and 20 percent lateral impact. [Note: Rails, end trucks and other crane components to be supplied and installed by others.]

3.11.3 Live load shall be 30 PSF minimum snow load plus drift load (1994 UBC App., Ch 16) with no reductions.

3.11.4 Wind load shall be based on 80 MPH wind with exposure-factor "C".

3.11.5 Earthquake design shall be for Seismic Zone 0, with importance factor 1.0.

3.11.6 Any additional requirements for the building structure to meet insurance's requirements should be identified separately as an option to the bid price (reference section 1.2 of these specifications).

3.11.7 All welded plate or hot-rolled sections shall conform to AISC specifications.

3.12 All cold-formed structural members shall conform to AISC specifications.

3.13 Girts and purlins to be stiffened-type, unless specified otherwise by building manufacturer or Owner.

3.14 Roofing shall be minimum 26-gauge, galvanized steel with baked enamel finish or "galvalume" (or approved equal) with stainless-steel fasteners. Roof shall be guaranteed for 20 years.

3.15 Siding shall be minimum 26-gauge, galvanized steel hi-rib, 3FT wide panels with baked enamel finish in a color to be specified by the Owner and expected to match existing metal buildings on site.

3.16 Trim shall be minimum 26-gauge, galvanized steel with baked enamel finish in a color to be specified by the Owner.

3.17 Wall insulation to be fire-rated R-19 minimum or greater if required by state energy code.

3.18 Roof insulation to be fire-rated R-19 minimum or greater if required by state energy code. Insulation to have 4mil white vinyl face with reinforcing scrim at 1/4" each way.

3.19 Roof ventilators shall be weatherproof, with adjustable dampers and bird screen.

3.20 Roof smoke vents (4 ft. x 8 ft.) are to be provided and installed per building drawings.

3.21 All doors to be weather-tight - top, bottom, and sides.

3.22 Man-doors shall be insulated hollow metal, 20-gauge minimum, flush-panel type, bonded to non-warping cores with one safety-glass window set in an 18-gauge minimum frame, 3FT wide, except as noted otherwise.

3.23 Roll-up door to have weather-tight inside roll-up casing to maximize overhead clearance.

3.24 Contractor to provide and install at all truck entrances standard pipe bollards to protect door and building entrances.

4 FABRICATION AND ERECTION OF STRUCTURAL STEEL

4.1 This division of work includes all labor, materials and services necessary for, and reasonably incidental to, the completion of all structural steel work as included in the scope of work outlined in these specifications.

4.2 Structural steel and plates shall conform to ASTM specifications A36, Tube Steel ASTM A 500 grade B, unless otherwise noted on the drawings.

4.3 Fabrication and erection shall be in accordance with current AISC specifications.

4.4 Columns shall be cut true at right angles with the column axis.

4.5 All joint surfaces shall be free of scale, slag, burrs, dirt and other foreign material that would prevent solid seating of parts.

4.6 Final leveling of steel structures shall be accomplished by checking top-of-steel in relation to specified elevations and not from the bottom of the base plate.

4.7 ASTM A325 bolts shall be tensioned by the turn-of-the-nut method.

4.8 All structural welding shall be done in accordance with the American Welding Society's D1.1 structural welding code. Field-welding on any building structure shall be done by an AWS certified welder. Certificate must be received by Owner before any welding may begin. This welding requires a special inspection.

4.9 All fillet weld sizes shall be pre-qualified joints in accordance with AWS D1.1, Section 2.

4.10 All structural members that require splice joints shall be pre-qualified, full penetration weld joints in accordance with AWS D1.1, Section 5.

4.11 All welding rod, wire, and materials shall be used in accordance with AWS D1.1, Section 4. Electrodes to be E70-XX.

4.12 Remove all rust, flux, Plant scale, weld spatter, dirt, and grease.

4.13 Paint surfaces according to the following specifications:

4.13.1 SSPC "Steel Structures Painting Manual", Volume 2, Systems and Specifications.

4.13.2 Paint shall be applied in accordance with SSPC-PA1 "Shop, Field and Maintenance Painting" and the manufacturer's labeled instructions and specifications.

4.13.3 Surface preparation shall be in accordance with SSPC-SP1 "Solvent Cleaning" and SSPC-SP6 "Commercial Blast Cleaning", and shall be subject to the Owner's inspection.

4.13.4 All structural steel to be painted with red oxide primer,.Miller S-364, or equal.

4.13.5 Structural steel top coat: Miller machinery enamel or better, color number and/or chip to be supplied by Owner.

4.13.6 Paint to be applied per manufacturer's specification to 3 – 5 mil dry film thickness (DFT) per coat.

4.13.7 Abraded and scarred areas on painted surfaces and connections shall be repaired with the same kind of paint and with a minimum dry film thickness equal to that previously applied to the steel.

4.14 All UBC and County Building Inspector required testing shall be performed on the bolted and/or welded joints on the structures. Any welds or bolted connection failing to pass inspection will be brought up to required specifications at no additional cost to the Owner.

5 FIRE WATCH

5.1 In all cases, Contractor is to adhere to Alliant Energy's burning & welding permit process to ensure that the plant security personnel are aware of all burning & welding that has occurred during the day.

5.2 In addition, Contractor must adequately wet down all affected areas prior-to and after burning or welding.

5.3 Contractor to supply a fire watch for at a minimum of one (1) hour after any cutting or welding has taken place.

June 28, 2002

STRUCTURAL SUPPORT STEEL
TECHNICAL SPECIFICATIONS

For

CHARITON VALLEY BIOMASS PROJECT
FUEL RECEIVING AND PROCESSING FACILITY

at

OTTUMWA GENERATING STATION (Chillicothe, Iowa)

Chariton Valley Resource Conservation and Development, Inc.
Centerville, Iowa

TABLE OF CONTENTS

1 SCOPE OF WORK

1.1 This division of work includes the supply and installation all structural steel as required to support all the equipment, walkways, mezzanine and work platforms as shown on the drawings and as described in project documents. It also includes the supply and installation of pipe bridge and supports, and gallery support bents.

2 GENERAL

2.1 All materials shall be new and of the latest design.

2.2 Workmanship shall be of best quality and in accordance with established trade standards.

2.3 Detailed specifications appearing on the drawings or accompanying a purchase order or contract take precedence over these standards.

2.4 All details of construction and materials, shown or as described by the drawings or specifications, which are subject to question shall be brought to the attention of the Engineer or Owner in writing by the Fabricator before the contract has been awarded. If no questions have been raised as above-stated, no allowance will be made for any misunderstanding.

2.5 The work shall comply in all respects with the drawings and the specifications and with all laws, ordinances, and regulations of federal, state and/or local authorities having jurisdiction. In case of conflicting requirements, the most stringent shall govern.

2.6 Changes may be made with the approval of the Engineer and the Owner when such changes become necessary or desirable. Additional payment cannot be authorized unless this has been done. Cost for change-orders must be approved by the Owner and a written purchase order issued before changes can be made.

2.7 Should any work be performed in non-compliance with the above, and without a purchase order and approval from the Owner, all costs arising therefrom shall be borne by the company performing the work.

2.8 All design work shall be done by a professional engineer registered in the state of the project.

3 FABRICATION

3.1 MATERIAL

3.1.1 All structural and miscellaneous steel shall conform to ASTM A36 unless noted otherwise. Steel pipe shall conform to ASTM A53, Grade B, Fy = 35ksi. Tube steel shall conform to ASTM A500, Grade B, Fy = 46ksi. All wide flange shapes shall be ASTM A572, Grade 50.

3.1.2 Welded connections shall be fitted and welded in conformance with latest AWS and AISC specifications using AWS/AISC certified welders.

3.2 WELDING

3.2.1 Square and bevel-groove welds shall be full-penetration (F.P.) welds unless noted otherwise. Square-groove welds may be substituted for bevel-groove

welds where permitted by AISC and AWS. Flare-bevel-groove welds are partial penetration (P.P.) welds, unless noted otherwise. At P.P. welds, minimum throat-thickness shall be at least 5/8 x wall-thickness of thinner plate joined.

3.2.2 All welding shall be performed in the shop, unless noted otherwise. Field welding is not permitted without prior written consent of Engineer.

3.2.3 All structural welding will have Special Inspections made in accordance with UBC 1701. Special Inspection is to be continuous visual inspection while welding is being done, except as follows:

A Non-destructive testing is required for complete penetration groove welds in joints and splices greater than 5/16 inches thick of primary members of moment frames, in seismic zones 3 and 4 only.

B Periodic visual inspection can be provided, rather than continuous inspection, for

1 Single pass fillet welds not exceeding 5/16 inches.
2 Floor and roof decking.
3 Cold formed studs and joists.
4 Stairs and railing systems.

C Welding that does not resist forces specified by the code do not require inspection.

3.3 PROTECTION OF SURFACES

3.3.1 Paint Specifications:

A Miller machinery enamel or equal, color number and/or paint chip to be supplied by Owner.

B Safety Orange - Miller OE 36, or equal.

C Safety Yellow - Miller OE70, or equal.

D Red Oxide Primer - Miller S-364, or equal.

E Specify brand of paint selected in your bid.

3.3.2 Remove all rust, flux, mill scale, weld-spatter, dirt, and grease.

3.3.3 Paint all items with one coat of Red Oxide Primer.

3.3.4 Paint support steel with one coat of green machinery enamel.

3.3.5 Paint handrails and toe boards with one coat of Safety Yellow Machinery enamel.

3.3.6 Stair treads to be galvanized.

3.3.7 Joints requiring field welding shall be left unpainted.

3.3.8 Coat all exposed machined surfaces with a suitable rust-preventative compound for protecting surfaces during shipment and erection.

4 ASSEMBLY AND SHIPPING

4.1 All support steel shall be as fully shop-assembled as possible in order to hold field-assembly to a minimum, subject only to shipping and handling limitations. See detailed drawings for field-joint locations.

4.2 Where necessary to ship in two or more sections, the unit shall be shop-assembled to assure proper fit and alignment, flanged for erection bolt connection, match-marked, and provided with bolts for field-assembly.

4.3 Shipping joints shall be welded after the support steel has been erected and aligned. Erection bolt connections shall be strong enough to support the unit during erection before welding.

4.4 Finished-metal surfaces shall be covered with a corrosion-resistant coating to protect the surface until installation.

4.5 A detailed manifest shall accompany each shipment.

4.6 Fasteners required to mount support steel in mill shall be provided by the Erector.

4.7 Each item of support steel will be identified by a section code number assigned by the Engineer. Fabricator shall clearly identify the item and each of its unassembled components by affixing the proper numbers by means of tags, metal stamps, neatly applied painted numerals, or other suitable means. The section number shall be readily visible, durable, and secured in such a manner that it will not be lost in transit or obliterated by the elements. This number shall also appear on the detailed manifest.

4.8 Small components may be boxed or crated for shipment with the box or crate bearing the section number. Components for different sections shall not be boxed together.

4.9 All items shipped loose are to be shipped with, and wired to, the section to which it will be field-installed.

5 FIRE WATCH

5.1 In all cases, Contractor is to adhere to Alliant Energy's burning & welding permit process to ensure that the plant security personnel are aware of all burning & welding that has occurred during the day.

5.2 In addition, Contractor must adequately wet down all affected areas prior-to and after burning or welding.

5.3 Contractor to supply a fire watch for at a minimum of one (1) hour after any cutting or welding has taken place.

June 28, 2002

ELECTRICAL AND UTILITIES INSTALLATION
TECHNICAL SPECIFICATIONS

For

CHARITON VALLEY BIOMASS PROJECT
FUEL RECEIVING AND PROCESSING FACILITY

at

OTTUMWA GENERATING STATION (Chillicothe, Iowa)

Chariton Valley Resource Conservation and Development, Inc.
Centerville, Iowa

TABLE OF CONTENTS

1 GENERAL

1.1 Perform work in complete accordance with all current applicable state and local Codes or Regulations unless Drawings or Specifications are more restrictive.

1.2 Before starting work, carefully examine site and all Contract Drawings to become thoroughly familiar with work conditions.

1.3 Verify all indicated elevations, building measurements, roughing-in dimensions and equipment locations before proceeding with work.

1.4 Observe all safety codes and regulations and good common practice in locating and installing mechanical equipment and material.

1.5 Do all necessary cutting and patching of existing surfaces required for completion of the Mechanical Work. Patch to match finish and color of adjacent surfaces.

2 SCOPE OF WORK

2.1 This division of work includes all labor, materials and services necessary for, and reasonably incidental to, the completion of all electrical power, electrical and controls work outside of vendor supplied electrical. The work as outlined in the project documents and as shown on the drawings provided and as specified below.

2.2 Power Distribution is to be provided and installed for the new switchgrass processing plant with storage barn facilities. This includes the design of the following, per the technical specifications.

2.2.1 New underground feed from the utility (13.8 KV) to new outdoor 15KV switches and dry type transformer(s) (13.8 KV/480 V and 13.8 KV/2.4KV). Sizing the transformer(s) from the motor list and the anticipated lighting and branch circuit loads.

2.2.2 The 2.4 KV system will feed all motors 200 HP and larger. The outdoor switch will be loop fed from the same utility feed as the 480 V transformer. It will the feed medium voltage switchgear, which will feed a medium voltage MCC.

2.2.3 Design of the 480 Volt distribution system, from the Secondary switchgear to the MCC Layouts and the power distribution panels. The cables from the transformer to the secondary switchgear shall be run underground, the MCC feeders shall be run overhead.

2.3 Provide all Process Building switchgrass storage barn, Gallery and outdoor lighting. This includes the design of the system per the design criteria and the technical specifications.

2.4 Provide and install all Branch Power for the facilities.

2.4.1 Processing Floor

A Supply and install conduit, wire, and duplex receptacles as per locations, branch circuits to be fed from power panels.

B Supply and install conduit, wire, and Welding receptacles as per locations, branch circuits to be fed from power panels.

2.4.2 Storage Barn Floor

A Supply and install conduit, wire, and duplex receptacles as per locations, branch circuits to be fed from power panel.

B Supply and install conduit, wire, and welding receptacles as per locations, branch circuits to be fed from power panels.

2.5 Motors

2.5.1 Supply and install Motor Circuits as per motor locations as described in the technical equipment specifications and based on the motor list. See also Drawings #732-7001 and 7002.

2.5.2 Supply and install local safety disconnects as shown on drawings. Furnish disconnects with quick make control contact & stop buttons.

2.6 Grounding

2.6.1 Design, install, and provide a complete grounding system per the design criteria and technical specifications. This includes, but not limited to, building ground loops, main transformer grounding and equipment grounding.

2.7 Controls

2.7.1 Contractor to furnish and install control all wiring including approved vendors pre-installed control wiring for the project.

2.7.2 Crane control-cab which computer system controlling the crane system will be provided by an approved vendors list. Contractor to purchase and installed, as received from vendor, and provide power interconnect wiring as required.

2.7.3 Provide 15% spare control conductors in addition to the number required.

2.7.4 Provide (1) #12 THHN Green per conduit.

2.7.5 Contractor to provide crane controls which will be approved by the owner using the approved vendor list. Electrical Contractor to work with crane control approved vendor for the complete installation of his system and provided components. The contractor is to complete the install from the system and components received. Vendor must provide assistance and technical information as needed at the cost of the contractor.

2.8 As Builds

2.8.1 Contractor to furnish Owner with updated drawings when the project is completed, the drawings shall include but not be limited to :

One-Line Diagram
Underground conduit or cable routings
Tray routings with elevations
Elementary Diagrams
Motor Locations
Interconnection Diagrams
Conduit and Conductor Schedule
PLC programs printouts
Wiring Diagrams

2.9 Demolition

2.9.1 Contractor is responsible for the demolition “as required” for the entire electrical aspects of this project.

2.10 Other Electrical and Control Contractors.

2.10.1 Contractor must work with other electrical and controls contractors for interfacing equipment and equipment controls.

2.10.2 Information to the extent of the scope for other electrical and controls contractors or expected supply vendors will be available during bidding and final scope and other information will be available at award.

2.10.3 The electrical contractor is to provide and install the new boiler control system which will interface with vendor supplied equipment and necessary boiler controls. The control system and monitor(s) are to be located inside the existing boiler control room, and an additional control monitor is to be installed in the process building office.

3 MATERIALS SUPPLIED BY CONTRACTOR

3.1 The Contractor must supply ALL equipment and materials required to complete the electrical and controls work, and test out the system.

4 MATERIALS & EQUIPMENT SUPPLIED BY OWNER

4.1 No materials or equipment is supplied by owner or the by the power plant.

5 EQUIPMENT PROVIDED BY OWNER FOR CONTRACTOR USE

5.1 The Contractor WILL NOT be allowed to use any of Owner’s or Alliant Energy’s plant rolling stock or other equipment at any time. All equipment AND OPERATORS must be supplied by the Contractor.

6 GENERAL SPECIFICATIONS

6.1 The intent of these specifications is to permit the Contractor to propose the materials and design which will provide the most economical system within the limitations outlined in this specification and as shown on the drawing(s).

6.2 Detailed specifications appearing on the drawings or accompanying a purchase order or contract take precedence over these specifications.

6.3 All details of construction and materials shown or as described by the drawings or specifications, which are subject to question, shall be brought to the attention of the Engineer or Owner in writing by the Contractor before the contract has been awarded. If no questions have been raised as above-stated, no allowance will be made for any misunderstanding.

6.4 The work shall comply in all respects with the drawings and the specifications and with all laws, ordinances, and regulations or authorities having jurisdiction. In case of conflicting requirements, the most stringent shall govern.

6.5 Should any work be performed in non-compliance with the above, or without a purchase order and approval from the Owner, all costs arising therefrom shall be borne by the company performing the work.

6.6 Changes may be made with the approval of the Owner when such changes become necessary or desirable. Additional payment cannot be authorized unless this has been done, and a written purchase order must be issued before any changes can be made.

6.7 Substitutions shall be by written request only to the Owner or Owners approved sole representative.

6.8 All work shall be completed in an adequate, safe, and neat manner, and shall be acceptable to the Owner.

6.9 Workmen shall be of best quality and in accordance with established trade standards.

6.10 All work shall be executed in a workman-like manner, and shall present a neat and mechanical appearance upon completion. The Contractor shall provide and apply touch-up paint to all equipment as necessary.

6.11 The Owner reserves the right to order the removal of any person who, in his opinion, is not qualified or cooperating with other craftsmen in the best interests of the job.

6.12 The Contractor shall provide all materials, suitable and in adequate quantity, required to accomplish the work specified.

6.13 All materials provided by the Contractor shall be new and fit for the purpose intended.

6.14 When job is complete, the work area must be left broom-clean.

6.15 All design work shall be done by a registered professional engineer, or as required by Iowa State law.

7 TECHNICAL SPECIFICATIONS

7.1 General

7.1.1 Equipment supplied by vendors and/or contractors shall be new and fit for the purpose intended and conform to the following list of plant standard parts unless prior arrangements have been made with plant electrical management personnel for substitutions.

7.1.2 Equipment supplied by vendors and/or contractors must always be officially approved and acceptable through certification by Underwriters Laboratories, Factory Mutual, Engineering Corp., or other such authority responsible for enforcing the safety provisions of the National Electrical Code.

7.2 Motor Control Centers

7.2.1 Motor Control Centers shall be Allen Bradley.

7.2.2 The electrical enclosure shall be NEMA 1 gasketed.

7.2.3 The enclosure shall be designed for mounting on 3” leveling channels.

7.2.4 The enclosure shall be designed for top or bottom entry of the incoming feeders and sized for 2-500 MCM conductors per phase.

7.2.5 Horizontal bus shall be 800 amp tin-plated copper, vertical bus shall be 600 amp tin-plated copper. Minimum bus bracing shall be 42,000 amp RMS symmetrical.

7.2.6 A copper ground bus (1/4" X 2") shall be install and run the full length of the enclosure.

7.2.7 Control power shall be provided by a control circuit transformer mounted within the starter compartment. The primary side of the control transformer shall have both legs fused, the secondary side of the control transformer shall have one leg fused and the other leg grounded.

7.2.8 Pull-apart type terminal blocks shall be supplied for the termination of control wiring. Power terminal blocks will not be supplied, an additional control terminal block shall be installed in lieu of the power terminal block. The power wiring will terminate at the starter unit.

7.2.9 Supply a door mounted 3-position maintained selector switch for each FVNR starter (HOA), for a reversing starter supply a 4-position selector switch. Switches shall be Allen-Bradley 800 T series.

7.2.10 A surge suppressor shall be installed on each starter coil.

7.2.11 Crimp lugs shall be used on all power and control wires (except on circuit breaker and control terminal blocks).

7.2.12 An engraved acrylic nameplate shall be attached to each starter compartment door.

7.3 Low Voltage Motors (480 Volt) Acceptable Manufacturers: Reliance

7.3.1 All motors shall meet the requirements of NEMA Standard No. MG-1and be designed, manufactured and tested in accordance with the latest applicable standards of ANSI, IEEE, ASTM and OSHA.

7.3.2 All motors shall be squirrel cage, induction motors suitable for 480 Volt, 3-phase, 60 Hertz operation. Motors shall be suitable for full voltage start with NEMA Design B starting torque.

7.3.3 All motors shall have totally enclosed fan cooled (TEFC) type enclosures. The motor frame, end bells and fan shroud shall be of cast iron construction. Provide cast iron inner bearing caps and motor end shields. Cooling fans shall be suitable for rotation in either direction, epoxy coated metal fans are preferred over plastic.

7.3.4 Motor stator windings shall be made of copper wire, all motors shall have Class F or better insulation and be capable of carrying full load continuously in an ambient of 40 degrees C with temperature rise, by resistance, of 80 degree C. Motors shall carry a 1.15 service factor.

7.3.5 Bearings shall be anti-friction ball bearings suitable for grease lubrication. Provide conventional "unsealed" bearings, requiring periodic renewal of lubricant. Bearing housings shall be equipped with grease inlets and outlets accessible for the exterior of the motor without disassembly. The grease outlet shall be provided with a removable 1 lb. relief valve or a plug fitting.

7.3.6 Motor nameplates shall be stainless steel and be attached to the motor with stainless steel pins. Shoulder pattern eye blots or built in lifting hooks shall be furnished for handling convenience. The eyebolts shall be fastened firmly to the motor with "lock-tite" or similar material to prevent easy removal of the bolt.

7.4 Variable Frequency Drive (480 Volt AC) Acceptable Manufacturers : Allen-Bradley

7.4.1 The drive system shall be factory wired, mounted and tested, in one self ventilated NEMA type 1 steel enclosure, arranged for conduit entry from above or below and suitable for mounting against a wall. Enclosures wider than 32" shall have double doors.

7.4.2 Each drive cabinet shall be furnished with a label on the outside surface of the door with the following or similar warning:

WARNING

THIS EQUIPMENT MAY RECEIVE ELECTRICAL ENERGY FROM MORE THAN ONE SOURCE. CHECK DRAWINGS AND OPEN ALL DISCONNECTS BEFORE SERVICING EQUIPMENT.

7.4.3 The incoming line equipment shall have a three phase, magnetic trip only molded case circuit breaker disconnect. Interrupting capacity of the breaker shall be at least 22,000 amperes (symmetrical). Circuit breaker shall be equipped with external operating mechanism, suitable for padlocking in the open position. Circuit breaker shall be mechanically interlocked with the cabinet door to prevent opening the door if the breaker is not in the open position, a means shall be provided to enable qualified personnel to bypass this mechanical interlock and open the door with the circuit breaker in the closed position. The circuit breaker shall disconnect all power from the system except any interlocking or instrument control power originating from a separate system. Barriers with warning labels shall be provided to isolate areas within the drive that may remain energized when the circuit is open.

7.4.4 The drive cabinet shall contain inverse-time thermal overload relays (one per phase) to shutdown the drive on sustained overload of the drive.

7.4.5 The drive cabinet shall contain a three phase power inverter/converter to provide adjustable frequency power. The invertor shall be of the pulse width modulated (PWM) type with a three phase, diode or thyristor.

7.4.6 An AC control transformer (with secondary fuse) for 120 VAC control circuit will be provided as well as current transformers and shunts for instruments and feedback required.

7.4.7 The drive controls shall be provided.

A Static phase sequence, single phase and ground fault protection

B Static instantaneous overcurrent protection

C Independently adjustable timed acceleration and deceleration (5-60 sec).

D Static over and under voltage and overcurrent protection for the DC bus.

E Static instantaneous overvoltage and over frequency protection circuits for the output bus.

F Speed reference shall be either a 4-20 ma signal from a process instrumentation source (by others) or from a increase/decrease discrete inputs. The drive shall have the capability for either.

7.4.8 Drives shall be capable of serial digital communication with a higher level of controller. This communication link shall be capable of receiving setpoint

information and drive state commands over the serial link. The communication link shall be capable of carrying drive status information and internal numeric register information from the drive to the higher level controller.

7.4.9 The drive digital controller shall be capable of using discrete inputs from dry contacts (drive to power the circuit) or a 120 VAC input from outputs of the users PLC system. The drive shall also provide 120 VAC outputs diving inputs on the user PLC system.

7.4.10 The following devices shall be furnished, mounted and wired on the enclosure door: "Power On" indicating light, fault indicating light and reset pushbutton, Keypad and display to provide access to software configuration functions and for display of internal numeric registers for diagnostics.

7.5 Cast Coil Transformer

7.5.1 Transformer Ratings

Primary Voltage	13.8 KV
Secondary Voltage	480 Volt
Primary Winding	Delta
Secondary Winding	Wye
Impedance:	8% Nominal
Primary Coil BIL	95 KV
Secondary Coil BIL	30 KV
Phase	3

Primary Voltage	13.8 KV
Secondary Voltage	2.4 KV
Primary Winding	Delta
Secondary Winding	Wye
Impedance:	6% Nominal
Primary Coil BIL	95 KV
Secondary Coil BIL	45 KV
Phase	3

7.5.2 The transformer shall conform to all current applicable standards on National Electrical Manufacturers Association (NEMA) and the Institute of Electrical and Electronic Engineers (IEEE), including

A ANSI/IEEE C57.12.01

B ANSI/IEEE C57.12.52

C ANSI/IEEE C57.12.70

D ANSI/IEEE C57.12.80

E ANSI/IEEE C57.12.91

F ANSI/IEEE C57.110

7.5.3 General Requirements

A The cast coil transformer shall be designed for a 80°C rise in a 30 °average, 40°C maximum ambient. The rise shall be determined by resistance, per ANSI/IEEE standards, the unit shall be designed for outdoor installation.

B The unit shall be a AA/FA unit and shall contain an indicating system for coil temperature.

C The unit shall be capable of being stored or operated at temperatures between -35°C and 50°C and up to 100% humidity.

7.5.4 Construction

A Coils shall consist of separate primary and secondary coils for each phase mounted coaxially.

B All coils are to be cast in molds under vacuum to assure complete void free resin impregnation throughout the entire insulation system.

C Each coil shall be supported on resilient pads to retain the coils while permitting them to expand. These pads shall be designed to provide some degree of noise abatement.

D Coils shall be designed and manufactured to withstand without damage the short circuit testing as defined in C57.12.01 and C57.12.91.

E The coils shall be of high conductivity copper. All coils will use 220°C rated insulation materials.

F The coils shall be rated and tested for BIL levels as follows: primary coil – 95 KV and secondary coil – 45 KV (2.4 KV) and 30 KV (480 V).

G The transformer core shall be constructed of high grade, grain-oriented silicon steel laminations with high magnetic permeability. Magnetic flux density is to be kept well below the saturation point.

H The core leg cross sections shall be uniform in shape with mitered joints to keep core losses, exciting current and noise levels at a minimum.

I The core shall be protected from corrosion by coating.

J All core laminations shall be free of burs and stacked without gaps.

K The core shall be visibly grounded utilizing a flexible copper conductor sized per ANSI/IEEE Standards.

L The primary and secondary bus shall be constructed of high conductivity tin plated copper. Bus shall be sized for the for the fan cooled ratings.

M Bolted connections shall be secured with cadmium plated steel bolts, Belleville washers will be used on all bolted bus connections.

N The primary bus shall be braced for 1000 MVA, the secondary bus shall be braced for 65,000 amperes (480 V) and 350 MVA (2.4 KV).

O The ground bus shall be ¼" x 2" copper, and shall extend the full length of the enclosure.

7.5.5 Transformer Enclosure

A The entire assembly may be disassembled and reassembled in the field without cutting or welding.

B Lifting provisions for the enclosure and the core / coil assembly shall be provided so they can be lifted together or separately in such a way that the core/coil assembly is suspended directly by lifting hooks.

C The base shall be constructed to permit rolling or skidding in any direction and will be equipped with jacking pads designed to be flush with the transformer enclosure.

7.5.6 Forced Air Cooling

A Fans will operate at 120 VAC via a contactor with overload protection and a contact output to signal a fan failure. All fans shall be wired in aluminum conduits. Thermal sensors will be wired in the hot spot of each coil.

B The fan controller will be of the electronic sensor type, the controller will be able to indicate the temperature at each sensor and display the maximum temperature recorded at each sensor.

C The fan controller will turn on the fans when the temperature reaches the AA rating. The controller will have two separately adjustable contacts for alarming and for tripping if the temperature continues to rise.

D The controller shall be able to manually operate the fans as well as cycle the fans periodically with internal circuitry or from a remote contact closure.

7.6 Low Voltage Switchgear

7.6.1 The switchgear shall be designed for use on a 600 volt, 3 phase, 60 hz system. All equipment shall be UL and Service Entrance labeled.

7.6.2 The main bus shall be rated at 4000 amperes minimum.

7.6.3 All bus shall be constructed of high conductivity, tin plated copper and shall be designed for the continuous bus rating. All connection and terminal bolting surfaces shall be tin plated. All joints shall have a minimum of four bolts. Bolted connections shall be secured with grade 5 steel bolts, nuts, doulble flat washers and Belleville washers.

7.6.4 The ground bus shall be ¼" x 2" high conductivity, tin plated copper and extend the full length of the switchgear.

7.6.5 The bus assembly shall be constructed so as to maintain the minimum UL electrical clearances without reliance on the use of insulating material.

7.6.6 Instrument, relay and control wiring within the equipment shall be #14 AWG minimum size, moisture-proof, 600 volt, 105°C, tinned copper, insulated wire. All control wires for interconnection within the equipment lineup or leaving the equipment shall be provided with barriered terminal blocks.

7.6.7 A customer interface terminal block shall be located in the auxiliary compartment or metering cubicle. This terminal block shall contain all customer interface connections and those connections shall be clearly identified on the drawings supplied with the equipment.

7.6.8 The enclosure shall be an indoor, NEMA 1 enclosure. Lifting eyes are to be provided with each shipping group. The base shall be constructed to permit rolling in any direction. All breakers and instruments shall face the front of the unit.

7.6.9 A front breaker compartment containing the drawout circuit breaker elements.

7.6.10 The bus compartment is to contain the section riser and main horizontal bus, which is to be rated for a 65°C temperature rise per ANSI standards.

7.6.11 Load terminations at feeder breakers shall be extended by bus bar from the rear of the breakers into the rear terminal compartment. The rear cable compartment is to accommodate all incoming and outgoing cable required within each vertical section. This compartment shall be full height, width and barriered from the main bus.

7.6.12 One top mounted traveling breaker lifting device shall be provided with the switchgear lineup.

7.6.13 Three current transformers of suitable ratio shall be provided to allow for phase protection and metering of all three phases. Current transformer terminal blocks shall be the short-circuiting type and shall be supplied for each set of current transformers.

7.6.14 One voltmeter and voltmeter switch to allow monitoring of all three phase line to line voltages shall be provided, one ammeter and ammeter switch to allow monitoring of all three phase currents shall be provided.

7.6.15 Three 50/51 protective relays shall be provided, these relays shall be timed and instantaneous, very inverse.

7.6.16 Circuit breakers shall be drawout type, manually or electrically operated. The breakers shall mount on a rigid self-aligning drawout mechanism with “connected”, “test”, “disconnected” and “removed” positions.

7.6.17 Padlocking provisions shall be furnished when the breaker is in the open position, positively preventing unauthorized closing of the breaker contacts. The circuit breaker door shall be operable when a circuit breaker is locked out. Provide interlocks to ensure the breaker is open before it can be moved from any position or when it is between positions.

7.6.18 The trip device shall be a microprocessor based with true RMS sensing. The trip device shall provide protection, information, integral testing, remote communications, system parameters, troubleshooting information and energy monitoring.

7.6.19 Acceptable manufacturers include, ABB, Cutler-Hammer and Siemens

7.7 15 KV Fused Load Break Switch, Outdoor

7.7.1 The switch shall be air insulated with three pole, gang operated, two position, stored energy lockable mechanism. A position indicator with positive determination of position shall be provided. The switch shall be rated 95 KV BIL, 40,000 amperes momentary withstand, 40,000 ampere fault-close. The switch shall be designed for a minimum of 1000 operations at rated current.

7.7.2 Connection between the switch and the transformer shall be insulated cable. Minimum cable size shall be 500 MCM and shall be supported and secured to the structure in a manner to provide a 4” to 6” separation between cables.

7.7.3 The switch shall be manually closed and the enclosure shall have a suitable interlock so that the door cannot be opened when the switch is closed and that the switch cannot be opened with the door open.

7.7.4 A 120 volt AC thermostatically controlled space heater shall be provided, a 13.8 KV- to 120/240 V, 1500 VA transformer shall also be provided to power the space heater.

7.7.5 Owner's cables shall be two 500 MCM per phase and enter through the bottom, at least a 29" allowance shall be provided for stress cone connections.

8 ELECTRICAL CONSTRUCTION SPECIFICATIONS

8.1 General

8.1.1 The Contractor shall perform the work and purchase equipment in compliance with the following listed and other applicable local and national codes, standards, and safety ordinances and any subsections thereof as applicable.

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
FM	Factory Manual
ICEA	Insulated Cable Engineers Association
ISA	Instrument Society of America
IEEE	Institute of Electrical and Electronic Engineers
NEC	National Electric Code (NFPA 70)
NEMA	National Electrical Manufacturer's Association
NESC	National Electrical Safety Code (ANSI C2)
NETA	National Electrical Testing Association
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Act
UL	Underwriters' Laboratory
UBC	Uniform Building Code, Zone 2B

8.1.2 The Contractor shall supply all construction materials, except for items specifically identified as furnished by the Owner, necessary to connect and make ready for service all electrical equipment shown on the drawings or indicated in the specifications.

8.1.3 Construction materials are specified on the drawings and in this document. Where materials have not been specified it is the intent of these specifications that only materials of high quality industrial grade be used.

8.1.4 Installation shall be in accordance with the Drawing and Specifications. Where drawings of technical specifications are not provided, the materials shall be installed in accordance with the Manufacturer's recommendations, where applicable, and shall conform to the accepted practice of the trade involved.

8.1.5 All required interconnections with the existing plant shall be made by the Contractor during the scheduled plant shutdowns if permission is granted by the Owner.

8.1.6 It is mandatory that the Contractor submit a procedure acceptable to the Owner for the energizing and de-energizing of all electrical equipment and a lockout/tagout procedure to prevent injury to personnel and accidental shutdown of operating equipment. In addition, contractor must adhere to plant electrical red tag and lock-out procedure when working on existing equipment.

8.1.7 Equipment manufacturer's installation instructions shall be strictly adhered to by the Contractor for installation of switchgear, load center unit substations, motor control centers, bus work, process control instruments, and all other equipment.

8.1.8 Location of equipment and outlets shall be checked at the site. When required, questions as to exact locations shall be submitted to the Owner for decision. The Owner reserves the right to make reasonable changes in location, before "rough-in", without additional expense to the Owner. All reasonable changes from drawings necessary to conform to the building construction and avoid conflict with work done by other trades shall be made by the Contractor without additional expense to the Owner.

8.1.9 Cable tray, channel, conduit and wiring shall be installed in such a manner as to avoid interference with equipment operation, removal, or access to equipment for maintenance purposes.

8.2 Motors

8.2.1 All motors shall be set true and plumb and in proper alignment with shafts or pulleys of the apparatus to be driven. Cable shall enter the side or bottom of terminal boxes and shall be so installed that liquids will tend to run off the surface rather than toward the motor fitting.

8.2.2 All motors shall be meggered when received, when removed from storage and during checkout. All three readings shall appear on a commissioning tag attached to the motor.

8.2.3 Electrical equipment tags shall be completed for each motor and attached to the controller door.

8.3 Panels

8.3.1 The Contractor shall furnish all lighting, service, and power distribution panelboards required. All panelboards shall be of deadfront construction and shall incorporate all switching and protective devices of the type, quantity, number of poles, and rating specified, or as shown on the drawings.

8.3.2 Relays, panels, cabinets, and equipment shall be level and plumb and installed parallel with structural building lines.

8.3.3 All panels must be labeled by UL.

8.3.4 Wall hung panels shall be supported by strut and mounted a minimum of ¾ in. from the wall.

8.4 Safety Switches

8.4.1 The Contractor shall provide all safety disconnect switches required except those specifically designated on the drawings, or within these specifications, as being "Owner-furnished". All safety disconnect switches shall be premium heavy duty rated for industrial uses, non fusible.

8.4.2 Enclosures and control devices shall be supported independent of conduit connections.

8.4.3 Base-plate of support brackets or stands shall be mounted off the floor on grout pads in all areas. Any exceptions must be approved by owner.

8.5 Cable Trays

8.5.1 Cable tray systems (tray and channel) shall be continuous from end to end using standard fittings and devices where the tray changes directions, elevations or branches.

8.5.2 Tray systems shall be installed so that the finished system will not have any sharp edges to damage cables.

8.5.3 All cable trays shall be marked with cable tray numbers where applicable as shown on the electrical drawings. Numbers shall be stenciled with black paint and visible from the floor below.

8.5.4 Where cable trays pass within 3 ft of potentially damaging heat sources, insulating barriers shall be installed between the trays and the heat sources to limit cable temperature to its design rating.

8.5.5 Contractor shall install firestops in cable trays consisting of spray-on fire retardant as required by all applicable codes.

8.5.6 The Contractor shall, before installation of any tray system material or supports, carefully check all routings for interference with building structure, piping, equipment, removal or maintenance of equipment, and work of other crafts.

8.5.7 Trays shall be supported at intervals not to exceed 10 ft. Channel shall be supported at intervals not to exceed six feet. Support spacing shall be such that supports shall not be stressed beyond their capacity.

8.5.8 Tray systems shall be firmly supported at ends where attached to panels, switchgear, cubicles, or other equipment, with tray manufacturer's recommended fittings or as approved by the Owner's representative.

8.5.9 Where penetrations through a wall are required, the tray shall be passed through a channel iron frame, covered with a 1/8 in. stainless steel plate and the opening around tray and conductors shall be completely sealed.

8.5.10 Cable tray expansion joints shall be provided in metallic tray systems at all building expansion joints. Tray shall be fastened firmly to its support. Expansion joints are not required in fiberglass tray systems.

8.5.11 All horizontal cable tray runs (including fittings) located outdoors (and indoors where specified), shall have peaked tray covers installed after cables have been pulled.

8.5.12 Cables shall be run in the trays to which they are assigned in the cable schedules or on the drawings. Cables shall be run straight and parallel within the trays.

8.5.13 All types of conductors shall be securely fastened to cable trays. All vertical runs shall be fastened on 3 ft centers. All horizontal or inclined runs shall be fastened on 9 ft centers.

8.6 Conduit System

8.6.1 Care shall be taken that all conduit runs form a permanent continuous electrical circuit. To ensure this, all thread joints shall be made up tight. Where conduits cannot be fastened to electrical enclosures with threaded hubs, a grounding type bushing shall be used. Except where noted, all bushings shall then be

connected together in series with No. 8 AWG copper wire and connected to the system ground.

8.6.2 Weatherproof expansion joints with bonding jumpers must be provided wherever conduit is 1-1/4 in. and larger and provided across all expansion joints.

8.6.3 Minimum size for exposed conduits shall be ¾ in. and for underground conduit shall be 1 in.

8.6.4 Rigid conduit shall not be connected directly to electrical equipment, i.e., motors, solenoids, etc., that is subject to movement or vibration.

8.6.5 Where conduits pass from areas of high humidity to cooler ambient temperature, they must be sealed on the humid side, with Crouse-Hinds Type EYS or EES or Appleton sealing condulets.

8.6.6 Care shall be taken to keep conduit away from hot pipes and, under no circumstances, shall they be installed less than 18 in. from such pipes 150 F or higher.

8.6.7 A pulling sleeve or "C" condulet shall be installed at a maximum of ever 100 ft. Condulets shall be Crouse-Hinds Form 7 for use with conduits 1 in. and smaller, and Form 8 for conduits 1-1/4 in. and larger, unless otherwise required.

8.6.8 Insulated bushings shall be hard plastic as manufactured by Steel City, OZ, or approved equivalent, and shall be used on all ends of conduit that are exposed.

8.6.9 Aluminum conduit is approved for general use.

8.6.10 In all areas conductors carrying serial communication pairs, selected signal wiring, and speed feedback signals of a pulse nature will be installed in rigid steel or PVC coated rigid steel galvanized conduit or steel jacketed cable.

8.6.11 The connection to all motor terminal boxes shall be American Brass Sealtite Type UA flexible with neoprene jacket conduit or the U.L. approved equal, except where Type TC cable is used. A Kellems grip shall be used for each TC cable, sized 3/#2 or larger, which is bottom fed and has a 90 transition to the terminal box.

8.6.12 Exposed conduit shall be installed parallel with, or at right angles to, the structural members of buildings. Vertical conduits shall be straight and plumb.

8.6.13 Conduit ends shall be cut square, interior edges reamed smooth, and conduit ends made up as tight and close as possible. Screw thread lubricants shall be used in making up all joints so that the joint may later be dismantled without danger of seizure. Approved screw thread lubricants containing powdered zinc or graphite shall be used.

8.6.14 Conduit and other raceways shall be installed in a manner that will prohibit the entrance of water, moisture, or any other contaminant at all instruments, push buttons, switches, panels, boxes or any other equipment or device. Satisfactory and adequate methods of installation, materials, sealing, breathing, drainage means, and physical aspects of installation shall be used to insure a proper minimum maintenance installation. Contractor shall use Crouse-Hinds EYS (or equivalent) conduit seals. Conduit or cable entry to electrical enclosures shall be bottom or side entry (top entry only with owner approval).

8.6.15 Where conduits terminate under gear and panels, O.Z. Type BL grounding bushings with bonding jumpers shall be installed.

8.6.16 Meyer hubs shall be used when entering panels or electrical enclosures.

8.6.17 Minimum spacing between conduit shall be 7/8 in.

8.6.18 The conduit racks shall be at least 25% wider than required for conduit to be installed under this Contract. Conduits leaving the rack horizontally shall be offset up or down so that future conduits may be installed in the extra space.

8.6.19 Conduit shall be supported at a spacing not exceeding 10 ft. n addition, 1 in. and smaller conduits shall be supported at a spacing not exceeding 7-1/2 ft. Conduit shall be attached to supports at this same maximum spacing by conduit straps.

8.6.20 Supports for groups of conduits shall be electrical supporting channel (such as Unistrut, Burndy, Flexibar or equivalent) of material compatible with the conduit system.

8.7 Underground Conduit

8.7.1 All underground conduit shall be Schedule 80 PVC or PVC Jacketed conduit unless completely encased in a concrete envelope.

8.7.2 Underground conduit systems shall be installed with sufficient depth to allow for future conduit runs.

8.7.3 All underground conduits shall be a minimum of 3 feet below grade and marked with tracer tape.

8.7.4 Unless trench sides are dug neatly, forms shall be used to maintain the dimensions of the conduit bank. Screed boards shall be used to insure that the specific cover is maintained on the top of conduits and that excess concrete, if used, does not obstruct future additions to the conduit bank. Forms and screed boards shall be removed prior to backfilling.

8.7.5 All conduit installed underground shall be exactly located “as built” on all applicable:

Electrical drawings.
Site development drawings.
Mechanical drawings.

8.7.6 For extensive runs (100 ft or more) monuments shall be installed such that the system can be exactly located. Where conduit is placed below a concrete or asphalt slab/roadway, the slab/road shall be painted with red stripes that extend one foot on either side of the conduit or duct for the entire length of the run.

8.7.7 Conduit envelope, if specified, shall be red 3000 psi concrete. EB duct is approved for use with concrete encasement.

8.8 Wires and Cables

8.8.1 Electrical and instrument wiring shall be in approved raceways and enclosures throughout. All low voltage cables shall be 600V tray-rated with the exception of cables run entirely in conduit. Instrument wiring in conduit systems may be 300V.

8.8.2 All wires shall be continuous, having no splices from terminal to terminal, unless otherwise indicated on the drawings.

8.8.3 Spare wires shall be neatly bundled up separately from the active wires; each wire marked “spare” and with point of origin. Wire shall be long enough to reach the farthest terminal within the enclosure. Insulate the ends of spare conductors. Coil spare conductors within the terminating enclosure.

8.8.4 All wiring shall be color coded per ICEA in a uniform manner throughout the plant. Color must be continuous over entire length of wire. Paint or taping of wire ends, except neutral and ground, will not be acceptable without owner approval.

8.8.5 Cable sizes No. 3 and 3/O will not be used.

8.8.6 Wire sizes shall be as shown on cable schedules or drawings but in no case shall be smaller than the following:

Power Circuits	No. 12 AWG
Lighting and Receptacle Circuits	No. 12 AWG
Control Circuits	No. 16 AWG
Instrumentation	No. 18 AWG

8.8.7 Do not exceed the manufacturer’s recommended maximum pulling tension during installation of wire and cable. Tension measuring devices shall be used for all circuits 300 ft or longer and all 15 kV cable.

8.8.8 All wiring in panel boards, cabinets, etc., shall be run in a plastic wiring duct (Panduit or an Owner-approved equal) unless otherwise approved by Owner.

8.8.9 Instrument, data or control wiring shall not be run in the same conduit system with power wiring.

8.9 Switchgear

8.9.1 The tightness of all connections (incoming busbar, terminations, mounting, etc.) shall be verified before releasing equipment for start-up. All bolts shall be drawn tight with a torque wrench to manufacturer’s specifications, and all joints shall be inspected before energizing.

8.9.2 Low voltage cables will be terminated using NEMA two hole, long barrel, copper, tin plated, circumferentially crimped lugs, (at least two crimps).

8.9.3 Prior to busbar termination, the bus termination surface shall be cleaned with all oxide removed.

8.9.4 Cable terminations to busbar will be made with SAE Grade 5, ½ in. -13 Cadmium plated hardware. Termination shall be made in the following sequence: bolt head, plated steel cut washer, busbar, terminal lug, plated steel cut washer, 1 Belleville washer (concave toward cut washer), and nut.

8.9.5 The busbar termination shall be covered with an approved heat shrink type sleeve.

8.9.6 All equipment required to be grounded by the NEC or by the inspecting authority shall be grounded whether specifically mentioned on the drawings or not.

8.9.7 All metallic conduits and wiring channels must be connected at one end to the grounding conductor with a good electrical contact.

8.9.8 All feeder conduits shall be bonded to both switchgear and motor control centers with No. 2/0 AWG copper conductor and approved grounding clamps and connectors.

8.10 Grounding

8.10.1 Building structural steel, utility bridges, conveyor supports, metal storage tanks and silos, process vessels and equipment or any structure of sufficient heights to attract lightning shall be grounded at 40 ft intervals (max.) and connected to ground grid with bare copper and ground wire.

8.10.2 The grounding mat shall be bare soft-drawn, stranded copper wire. When used as part of the ground grid or gradient control system, the grounding wire shall be buried a minimum of 18 in. below final grade.

8.10.3 The grounding electrodes shall be #4/0 bare copper wire connected to piling under the structure to be grounded. Where piling is not installed, use three copper-weld ground rods ¾ in. diameter, 10 ft long driven outdoors in a triangular formation on 6 ft centers.

8.10.4 Ground rods, when used, shall be driven in 10 ft lengths. Rods shall be driven and not jetted.

8.10.5 Underground connections and connections to building steel and equipment shall be by hydraulic compression type connector, unless otherwise noted on the applicable drawings.

8.10.6 Ground cable stub-ups through concrete from the underground grid to building steel and equipment shall be enclosed in 1 in. schedule 80 PVC conduit, with a minimum 2 in. projection above finished surface. The conduit shall be sealed with fire resistant foam.

8.10.7 Power transformers shall have at least two housing ground pads connected directly to the main ground grid.

8.10.8 Switchgear and motor control centers shall have ground buses connected at both ends directly to the main ground grid with bare copper.

8.10.9 Free-standing instrument and control panels shall be grounded directly to the main ground grid. PLC processor cabinets and control circuits for variable frequency drives shall utilize a common ground bus, isolated from other grounded equipment or conductors until connected to a single point of the ground grid with an insulated No. 2/0 AWG grounding conductor.

8.10.10 Lighting transformers shall have neutrals and cases connected directly to the main ground grid via grounding conductors associated with feeders.

8.10.11 Lighting panels shall be grounded, via and insulated copper conductor in the feeder conduit, to the power source equipment or via bare copper conductors in multi-conductor feeder cable to the power source equipment ground.

8.10.12 All lighting fixtures shall be grounded.

8.10.13 Power panels shall be grounded directly to the main ground grid with bare copper conductor.

8.11 Lighting

8.11.1 The Contractor shall furnish all lighting fixtures and lamps for the lighting system, as specified on the drawings. All lighting fixtures shall be cleaned and lamped at the time of final inspection. All panel schedules shall be complete and typed.

8.11.2 Lighting system voltages shall be 120V/208V, 3-phase, 4-wire, 60 Hz. Fixtures 400 watt and below shall be 120V.

8.11.3 Lighting fixtures to be energy-efficient type. Outdoor lighting shall have photo-cell control with contactors, unless otherwise noted on drawings.

8.11.4 When required, fixtures shall be supplied with couplings or end caps.

8.11.5 Lighting wiring runs shall be concealed in areas where construction will permit, such as office areas.

8.11.6 Fixtures installed under this work shall be properly and adequately supported from the building structure, except where ceiling construction or other provisions are specifically designed to support the fixture units. Fixture supports shall provide proper alignment and leveling of fixtures, and shall be arranged to maintain the alignment at all times. Fixture support material shall be provided and installed by the Contractor.

8.11.7 Mounting heights from finished floor to top of electrical equipment shall be as follows, unless otherwise indicated in drawings.

Convenience receptacles in plant area	3 ft-6 in.
Convenience receptacles in office area	1 ft-6 in.
Local lighting switches in plant area	4 ft-6 in.
Local lighting switches in office area	4 ft-6 in.
Lighting panelboards to TOP	6 ft-6 in.
Circuit breakers (operating handle)	5 ft-0 in.
Safety switches (operating handle)	5 ft-0 in.
Power receptacle, separately mounted	3 ft-6 in.
Combination motor starters, separately mounted (operating handle)	5 ft-0 in.
Push button stations, separately mounted	5 ft-0 in.

8.11.8 Boxes, panels, and enclosures for electrical wire, cable, and equipment shall be surface or flush mounted as indicated on drawings, shall be set true and plumb, and shall be secured rigidly to building, supporting steel, or masonry walls with approved attachment fittings.

8.12 Control Components and Wiring

8.12.1 Contractor is responsible to provide all control components and wiring for the project.

Item	Manufacturer
Terminals Blocks	Allen-Bradley
Terminal Strips	Allen-Bradley

Item	Manufacturer
Compression Lugs	T & B
Wire Tag Numbers	Brady
Fuses	Bussman
Duplex Receptacles	Hubble
Single Pole Switch	Hubble
3-Way Switch	Hubble
Cord Caps	Hubble
Welding Receptacles	Crouse-Hinds 60A
Flex Conduit	Anaconda
Condulets (Ts, Cs, LBs, etc.)	Appleton
Cables	Belden
Wire (600V)	Stranded, THHN or THWN, 90°C

8.12.2 Motors and Controls

Item	Manufacturer
MCCs	Allen-Bradley
Starters	Allen-Bradley
Control Buttons	Allen-Bradley
Solid-State Controllers	Allen-Bradley
Industrial Cont. Relays	Allen-Bradley
Timing Relays	Allen-Bradley
Plug-In Relays	Electromatic
Safety Switches	Allen-Bradley
AC Motors	Reliance
Frequency DRs	Allen-Bradley
Solid-State DRs	Allen-Bradley
Solid-State BRKs	Brake-Tron

8.12.3 Machine-Mounted Devices

Item	Manufacturer
Limit Switches	Cutler-Hammer
Encoders	B.E.I.
Motion Switches	Allen-Bradley
Pressure Switches	Square D
Float Switches	Square D

Item	Manufacturer
Photo-Electrics	Opcon
Proximity Switches	Opcon
Electric Clutch/Brake	Warner

8.12.4 Consoles and Panels

Item	Manufacturer
Junction Boxes	Hoffman
Consoles	Hoffman
Panels	Hoffman
Wire Duct	Panduit

8.12.5 Communications

Item	Manufacturer
Intercom Systems	Gai-Tronics
Video Cameras	Panasonic or Approved Equal
Video Monitors	Panasonic or Approved Equal

8.12.6 Computers and PLCs

Item	Manufacturer
Programmable Controllers	Allen-Bradley
PLC Software	Allen-Bradley
Computers	IBM or Equal, Pentium 4

9 ELECTRICAL DESIGN CRITERIA

9.1 Control System

9.1.1 Control System Power

A Electrical control system power shall be distributed by means of a circuit-breaker panel in each major control enclosure. Each control circuit shall be protected by a fuse with grounded neutral on opposite leg for all 120 VAC circuits. Control circuits shall be sub-fused where possible to eliminate many devices on one major fuse.

B Each low-voltage DC circuit shall be protected with a fuse. NEMA Class II wiring standards shall apply (NEC article 725).

C Isolation transformers/regulators (constant voltage control) shall be installed to protect computers and critical processors.

D All equipment furnished shall be connected to the building (secondary) ground grid, with the exception of previously described isolated ground requirements (see article 645 of the NEC). The minimum size insulated

stranded copper wire for controller equipment ground shall be No. 6 AWG. Controller/chassis ground wire shall be independent of grounds present on power conductor leads.

E All control devices on a piece of equipment are to be wired to terminal strips within a central control or terminal box. Terminals are to be accurately labeled according to wiring diagrams and schematics. Splices and wire nuts are unacceptable. Terminal strips shall contain 20% spare terminals. No more than two wires shall be installed at each terminal point.

F Where a control device must be adjustable or movable, wiring shall be type SO cord with sufficient slack to allow range of adjustment or movement. Cord shall be connected to conduit body or box with CGB fitting. The SO cord will have a sufficient number of conductors to supply a separate grounding conductor at the device it is connected to.

G All equipment shall be identified with the plant standard label with black letters on a white background. Labels shall be of an appropriate size for the equipment.

H A single contact from each control device shall be connected to a single input of the PLC.

I Parallel or series contact connections will not be externally wired to the PLC.

9.1.2 Operator Devices

A Stop devices shall be specifically in the normally closed (NC) configuration, wired to a single PLC input for fail-safe operation.

B All operator control consoles shall be wired with supply voltages no greater than 24 volts DC. This shall include control power devices.

9.1.3 Programmable Controllers

A All output points must be individually fused through swing-arm fusing when individual fuses are not available on the output module.

B The PLC system shall have a minimum of 20% spare input points and 20% spare output points available for each type of module.

C All PLC hardware will be mounted in NEMA 12 enclosures. A 120 VAC electrical outlet will be proved near each enclosure to provide power for programming/trouble-shooting equipment.

D PLC shall be Allen-Bradley ControLogix or CompactLogix.

E Each PLC shall be able to communicate with the HMI computers through a RXLinx.

F All PLCs shall also have a RS-232 local port available for connection to a laptop computer for programming monitoring or modifications.

9.1.4 Programmable controller documentation shall include:

General Arrangement Drawing
Enclosure / Back Panel Layouts
Operator Control Panel Drawings
Control Power Distribution Drawings
System Interconnect Drawings

I/O Listing Drawings
Ladder Logic Diagrams
Memory Maps as required
Device Wiring Drawings

9.1.5 HMI Software shall be RSView by Rockwell Software.

A There will be three operator stations, one located in the Boiler Control Room, one located in the Processing Building and one located in the Unloading and Storage Building crane operators cab.

B The cranes in the Unloading and Storage building will be controlled by a screen located at the local operator station in the building. The crane controls will able to be transferred to the operator station in the Boiler Control Room, when the Unloading and Storage Building is not manned.

C The station in the Processing Building will control the PLC functions in the processing building. The station will also be able to monitor the operations in the Unloading and Storage Building.

D The Station in the Boiler Control Room will monitor the screens of the other two stations. It will not be able to control the other stations unless control is passed from the other station, this will occur only when the other stations are to be unmanned.

9.1.6 Computers

A Separation of low-voltage DC / high-voltage AC power shall be done by the use of separate wireways/conduits where possible, and barrier strips to provide protection under other conditions.

B Power conditioning required for computer/scanners shall be supplied with the equipment.

C Complete documentation is required for all computer systems.

D All computer/scanning systems shall be backed with complete diagnostics and troubleshooting aids.

9.2 Grounding Design Criteria

9.2.1 General

A The grounding circuit shall consist of electrodes driven in earth, a loop connected to the electrodes, and a grid interconnecting to the loop. To this circuit, equipment and building grounds shall be connected. Grounding shall be in accordance with NEC and IEEE Standard #142-1982 otherwise referred to as the IEEE “Green Book”, “Grounding of Industrial and Commercial Power.”

B Detailed specifications shall indicate the extent of each grounding circuit.

C Each grounding circuit shall be designed so that the grounding resistance of the circuit may be readily checked at any time.

D Each grounding circuit shall have a resistance of not greater than 1.0 ohm.

E A hydraulic compression process of making connections shall be used for:

1 All underground cable connections.

2 All ground cable traps.

3 Any non-accessible ground connections.

F Where ground bus or cable passes through steel barriers, the bus or cable must be securely bonded to such steel to prevent choke effect.

G All contact surfaces to be thoroughly cleaned of dirt and oil to insure best contact.

H Contractor to provide and install all lights and lighting for the project.

9.2.2 Grounding Electrodes

A The minimum grounding electrode shall consist of three copper-weld ground rods one inch diameter, 8 feet long (minimum) driven outdoors in a triangular formation on 6 foot centers and interconnected with bare #2/0 AWG cable.

B Sufficient grounding electrodes shall be installed to ensure ground system resistance of 1.0 ohm or less.

C The ground rods shall be driven to a depth so that the top of the rod shall be at the same elevation as the top of the foundation footer. Interconnection cables shall be a minimum of 12 inches below finished grade.

D Each ground electrode shall be connected to a #2/0 AWG bare cable terminating at a ground station mounted on structure to be grounded.

E Column ground stations shall be installed as follows: A 4” x 2” plate will be welded to the column or to a stiffener plate on the column base and the ground cable bolted to this plate.

F The centerline of ground terminations on columns shall be approximately 18” above finished floor.

G The termination of the #2/0 AWG bare cable shall be a Burndy Cat. No. VVA34-2N connector bolted to the copper bus with two ½ inch diameter bolts, nuts, flat washers and nuts.

H The bare #2/0 AWG cable shall be either looped under the building foundation or brought through the foundation in a chase consisting of a 3/4-inch PVC schedule 80 nipple extending through the foundation.

9.2.3 Grounding Loop and Grid

A Each building shall have a grounding loop and grid.

B A minimum of two (2) grounding electrodes as defined above shall be provided for the grounding loop and grid in any building up to 10,000 square feet ground area.

C A minimum of four (4) grounding electrodes as defined above shall be provided for the grounding loop and grid in any building of over 10,000 square feet ground area.

D The grounding electrodes shall be located near diametrically opposite corners of the foundations where two (2) are required and near each corner where four (4) are required. They shall not be located, however, where they may be under any roadway, passageway, or storage area.

E The grounding loop shall be a single loop of bare #4/0 cable laid in the earth below any concrete floor along the periphery of the outside foundations and inside theses foundations.

F Each section of grounding loop shall be terminated at the two (2) nearest adjacent terminals of the grounding electrodes.

G The connections of the ground loop sections shall be made as described previously.

H Grounding conductors laid underground, shall, unless otherwise mechanically protected, be laid slack to prevent their being readily broken.

I Each alternate building or column shall be connected to the ground loop or grid with #2/0 AWG copper cable. This cable shall be connected to a plate attached to the building column.

9.2.4 Equipment Grounding

A Enclosures and /or frames for motor starters, breakers, safety switches, switchgear, panelboards, motors, generators, capacitors, and exposed metal parts of similar equipment, shall have solidly grounded cable connections to the grounding system. NO solder lugs shall be made in a manner to insure a permanent ground.

B Towers, vessels, tanks, etc., supported on concrete foundations or piers, shall be solidly grounded with cable connections to the grounding system. Large earth bearing storage vessels do not require grounding.

C Steel structures shall also be grounded. Any tower, vessel, tank, etc., supported by a grounded steel structure, shall be considered grounded.

D All electrical equipment shall be individually grounded.

E The non-current carrying housing of portable equipment, shall be connected to the ground system by means of a grounding conductor.

F Stationary equipment, isolated from grounded steel work by reason of concrete construction, shall be effectively grounded by the use of copper ground wire bonding the equipment to the station ground, or other permanently grounded structures. The uses of conduit connections to equipment for ground will not be accepted as satisfying the grounding of isolated equipment for motors 60 HP and over.

G Grounding conductors for motor shall be connected to the MCC ground bus where possible. The MCC ground bus is part of the building ground system. Medium voltage motors also shall have an equipment ground from the motor base to the grounding grid.

9.2.5 System Grounding

A The secondary of all alternating current distribution systems which are to be grounded, shall have the common or neutral conductor connected to a grounding electrode and/or the grounding system at each individual service, and the grounding connection shall be made on the line side of any secondary disconnecting device.

B Secondary alternating current systems shall be grounded, as a general practice, where the voltage to ground does not exceed 300 volts.

C Lighting and control panels shall be provided with an individual ground wire connected to the system ground. The conduit system shall not be considered as an adequate ground.

D The 120/208 volt lighting system shall have a grounded neutral, with connection to ground grid made at the transformer "XO" terminal.

9.2.6 Ground Conductor Size

A Motors and service equipment are normally grounded with an internal grounding conductor in Type TC or MC cables. Separate grounding conductors, tied directly to the ground grid, are also required for all 2300 volt motors, DC motors, transformers, switchgear, MCC's, drive cabinets, lighting and other power panels.

B Equipment grounding conductor size shall conform to the following:

Control stations and motors under 5 HP*.....# 6 wire
5 HP to 25 HP*.....# 6 wire
30 HP to 200 HP A.C.*.....# 4 wire
1 HP to 50HP D.C.....# 4 wire
Above 50 HP D.C.....# 1/0 wire
Above 200 HP A.C.....# 1/0 wire
15KV power transformers and switches.....# 2/0 wire
Switchgear .....# 2/0 wire
Motor Control Centers.....# 2/0 wire
A.C. and D. C. Drive Cabinets.....# 6 wire min.
Lighting transformers and panels .....# 6 wire min.

*When required in conduit systems. NEC paragraph 351-7 allows flexible conduit as grounding means for 1-1/4 and smaller trade sizes, (60 HP and smaller motors at 600 volts).

For "internal" grounding conductors, use N.E.C. Tables in Article 250, "Grounding."

9.3 Lighting Design Criteria

9.3.1 General

A Contractor to provide and install all lights and lighting for the project.

B Lighting systems shall be 120/208 volts, 4 wire, three phase, 60 cycle.

C High bay areas shall be considered as those in which the lighting fixtures may be mounted 22 feet or more above the floor.

D Flood lighting shall be on 208 volt, 60 cycle circuits. All other lighting shall be on the 120/208 volt system as appropriate.

E Minimum wire size in any circuit, exclusive of the fixture wire, shall be #12.

F Lighting transformers, lighting and distribution panels shall be located, insofar as possible, in the electrical rooms.

9.3.2 Fixtures

A Control pulpits, locker rooms, offices, control rooms, laboratories, shall be illuminated by fluorescent fixtures furnished with certified high power rapid start ballasts.

B Outside areas not designated above shall be illuminated by HPS floods.

C Connections for lighting fixtures shall be made with plug and receptacle where practical. Standard U-blade grounding type shall be used for 120 volt, twist-lock type for 208 volt.

D Guards are to be provided on all lighting fixtures subject to possible physical injury, or over equipment where a falling globe could cause damage.

E Lamps of the type and size required in each lighting fixture shall be installed as specified.

F Installation details shall be prepared for typical lighting fixture assemblies.

G Ballasts for fixtures located in unheated areas shall be capable of starting the fixtures at temperatures of +10 degrees Fahrenheit.

9.3.3 Lighting Transformers

A Lighting transformers to supply the 120/208 volt system shall be rated 50 KVA minimum, three phase, 60 cycle, primary 600 volts with 2-2 ½% full capacity taps above and below rated voltage.

B Lighting transformers for indoor installation shall be dry type, Class F 80 C. rise, 2.4% impedance, and with corrosion resistant treatment.

C Lighting transformers shall not be initially loaded to greater than 80 percent of capacity.

D Transformer shall be fed from the nearest process related MCC and protected with a thermal/instantaneous breaker.

E The neutral of the lighting transformer shall be grounded to the building grounding system.

F Lighting transformers shall normally be fed from 480 V feeder, provided that the available short circuit current does not exceed 25,000 amperes (symmetrical) at the point of connection. The line impedance may be included in determining the short circuit value.

9.3.4 Lighting Panelboards

A Lighting panelboards shall be rated 120/208 volts, 3-phase, 4-wire, 60 Hertz, copper bus, main breaker, door-in-door construction, and provision for a minimum of 30 single pole breakers.

B Individual breakers shall be bolt-on type, rated at a minimum of 15 amperes and a maximum of 50 amperes. Provisions for locking each breaker open shall be provided.

C The arrangement of main buses and main or branch circuit breakers, the connected load on each phase (leg) with directory identification for each branch circuit, shall be shown on a schedule prepared for each panelboard.

D The main circuit breaker shall be positioned so that the handle is down when the breaker is in the “Off” position.

E The panelboard neutral and ground buses shall be kept separate, and each shall grounded to the ground grid at the lighting transformer from which it is fed.

9.3.5 Branch Circuits

A Branch circuit breakers shall not be loaded to exceed maximum of 75 percent of their ampere trip rating.

B Lighting fixtures and 110 volt convenience receptacles shall be on 120/208 circuits fed from lighting panels. Normally these circuits shall be connected to a 20 ampere breaker.

C Contractors for outside area lighting control shall not feed a normal load of greater than 70 percent of their rated ampere capacity. Control shall be by a photo-electric switch wired through an "Auto-Off-Manual" selector switch. "Manual" shall override the photo switch.

D Ground fault protection shall normally be provided by GFCI type circuit breaker in the lighting panel.

E Where surge suppression is required for electronic equipment protection, provide Hubbell #5352-S duplex receptacle on the 120VAC branch circuit.

F Three phase lighting circuits shall be color coded as follows:

Phase	Color
A	Black
B	Red
C	Blue
Neutral	White

9.3.6 Emergency Lighting

A Battery fed emergency lighting units shall be located at all control rooms and any other area where lighting failure may create and extreme personnel hazard or may seriously disrupt operations. Fluorescent fixture with integral battery pack is preferred for electrical and control rooms.

B Each unit shall be on automatic charge when connected to 120 volt, single phase, 60 cycle source. Connection shall be for an armored cable or conduit fed from lighting panel.

C Each unit shall contain a 6-volt or 12 volt sealed maintenance-free lead acid battery and a completely automatic hi-lo rate charger having sufficient capacity to restore the battery to full charge following a 1-1/2 hour emergency discharge within 12 hours. It shall contain a front-mounted "Ready" switch and amber light, which shall indicate when the unit is in a position to give emergency lighting protection. A red light to indicate high rate of charge and a front mounted press-to test switch for quick check of lamps and battery.

D Unless otherwise specified, each unit cover shall mount two (2) directionally adjustable 25 watt sealed beam lamps.

E Each unit shall be provided with a wall mounting bracket.

9.3.7 Illumination Levels

A General illumination levels based on a maintenance factor of 0.70 shall be as currently recommended by I.E.S. However, the following specific minimum levels shall be provided:

Area	Foot Candles
Control rooms	Two-level, 50 & 100
Offices	Two-level, 50 & 100
Laboratories	Two-level, 50 & 100
Machinery rooms (Motor & Pump rooms)	50
High bay areas (operating floors, turbine rooms)	30-60
Low bay areas (Basements, stock prep, machinery areas)	10-40
Storage areas	10-20
Conveyor junction and transformer houses	30
Boiler room (upper level platforms, basements, etc.)	10
Railroads and roadways	5
Outdoor storage areas	5
Maintenance shops	50
Electrical equipment rooms	50
Instrument rack rooms	50

B Conveyor Gallery Lighting, provide 10 F average along entire length of gallery with 3 F minimum at extreme side limits of gallery and 5 F minimum on conveyor belts between fixtures.

10 ELECTRICAL SAFETY STANDARDS

10.1 National Electrical Code (NEC): All county, state, and federal regulations covering electrical work shall be adhered to at all times. The latest version of the NEC will be the guideline for all work.

10.1.1 Grounding:

A All conduits will be terminated at the entrance to any enclosure with approved grounding type bushings or hubs.

B A separate grounding conductor of the approved size and color will be run in every conduit or wireway.

C All grounds will be terminated to the plant building ground system (except special computer and electronic equipment requiring isolation as provided for in article 645 of the NEC).

10.1.2 Housekeeping:

A All loose debris, wiring, fittings, conduit, parts and tools shall be removed from the work area at the end of each job and/or shift. The area will be cleaned as to prevent safety hazards.

B All electrical enclosures will be returned to a secured and latched condition at the end of each job and/or shift.

C Wireway and conduits will have their covers installed and wiring placed inside in a professional and orderly manner when each job is complete.

10.1.3 Equipment Labeling:

A Each feeder, branch circuit, and power source will be identified and labeled at the source and destination termination with the properly-sized and worded labels

B Each power distribution panel, transformer and power supply will be identified and labeled with the plant standard identification code for electrical equipment.

C Each conduit shall be labeled with the plant standard identification at the point of origin and at the destination.

D Each motor will have a properly-sized, plastic engraved tag with the plant standard MCC identification attached to the conduit as close to the motor as possible.

E Enclosures which house equipment using, or J-boxes used for, conduit and wire runs of higher than 480 volts nominal will be labeled with warning signs to specify the voltage level in each.

11 TESTING

11.1 The work shall include complete testing of all equipment and wiring at he completion of the work, and the making of any minor connection changes or adjustments necessary for the proper functioning of the system and equipment. Power distribution, lighting, control, and all miscellaneous systems shall be properly adjusted and in working order, as required, at the time of final acceptance.

11.2 Testing of any equipment or system shall not proceed until the installation is complete and ready for testing, as certified by the Contractor and Owner's representatives.

11.3 Safety rules and good common sense shall be observed at all times to ensure the safety of personnel. Equipment shall not be tested while being worked on by any craft. Adequate barriers or posted observers shall be placed to warn of possible danger during testing.

11.4 All test equipment specified herein or on the drawings shall be furnished by the Contractor and must be approved by the Owner in writing. Such equipment shall be in first-class condition, correctly calibrated, and operated by qualified personnel experienced in the use of the equipment. All test equipment shall be calibrated within 90 days prior to acceptance testing. Calibration accuracy shall be traceable to the National Bureau of Standards within three generations. Equipment generally required will be (1) megger(s) with settings of 500 VDC, 1000 VDC, and 2500 VDC, (2) volt ohmmeter (VOM), (3) clamp-on ammeter, (4) phase rotation meter, (5) High potential tester.

11.5 All testing shall be witnessed by the Owner or Owner's representative. The results of all quantitative tests shall be furnished to the Owner in writing within two weeks after tests. All readings taken shall be recorded.

11.6 All test results must be accepted by the Owner before the Contractor is relieve of responsibility for work. All test results shall be turned over to the Owner as part of the record documentation.

11.7 Megger tests shall not be made on any equipment until the manufacturer's instructions have been checked and an inspection made to see if any components such as semiconductors, control relay coils, etc., exist that may be damaged by such tests. Such components shall be isolated from the test potentials before the tests are performed.

11.8 Megger and D.C. high potential tests performed on wiring, switchgear, motors, generators, and transformers shall be done before application of normal power to these material and equipment.

11.9 The Owner shall be notified in person or in writing at least 24 hours prior to performing any test required in this specification. All testing shall be performed in cooperation wit manufacturer's representative. All necessary adjustments for proper component and equipment operation shall be the responsibility of the Contractor, under the supervision of the Owner or equipment manufacturer.

11.10 Megger readings shall not be recorded until meter reading has stabilized for two seconds.

11.11 Electrical equipment checklist tags shall be used to record all testing. A tag shall be placed on each piece of equipment. For motor control centers, a tag shall be placed on each starter door. Each checklist tag shall be signed off by the Contractor and the Owner's representatives when each stage of the testing is completed.

11.12 The contractor shall be responsible for the electrical safety of new equipment during installation and testing. Minimum requirements for lock-out and tag-out of electrical devices are covered in the contract documents, and compliance will be monitored by the Owner's representative.

11.13 Approval of all test results must be obtained from the Owner. All failures under a test due to defective material or poor workmanship shall be corrected at no expense to the Owner.

12 DISPOSAL OF MATERIALS

12.1 All scrap materials or materials resulting from demolition must be removed from the plant site and properly disposed of at Contractors expense.

13 INTERFERENCE WITH PLANT OPERATIONS

13.1 Contractor must avoid conflict and shall not interfere with the operation of the plant at all times during the project.

13.2 The plant normally operates fourteen 12-hour shifts per week (24 hours a day, 7 days a week), with shift hours as follows:

DAY SHIFT: 7:00 a.m. to 7:00 p.m. (Monday through Sunday)
NIGHT SHIFT: 7:00 p.m. to 7:00 a.m. (Monday through Sunday)
MAINTENANCE SHIFTS: 7:00 a.m. to 3:30 p.m. (Monday through Friday)

13.3 Friday, Saturday and Sunday operating shifts are infrequent but may be scheduled during the project, and Contractor will have to re-schedule tasks if conflicts arise. These extra operating shifts are scheduled will in advance, so adequate notification will be given.

14 CONSTRUCTION UTILITIES & FACILITIES

14.1 Owner will provide temporary power and water to the jobsite for use during construction.

14.2 Restroom facilities for use during construction shall be provided by the Owner as long as Contractor's employees show respect for those facilities. If cleanliness issues arise out of contractors misuse of the facilities provided, the contractor will be required to provide temporary facilities for his employees.

14.3 Lunchroom facilities for his own employees must be provided by the Contractor as Alliant Energy's and Chariton Valley RC & D's lunchroom facilities will not be allowed to be used by Contractor.

15 FIRE WATCH

15.1 In all cases, Contractor is to adhere to Alliant Energy's burning & welding permit process to ensure that the plant security personnel are aware of all burning & welding that has occurred during the day.

15.2 In addition, Contractor must adequately wet down all affected areas prior-to and after burning or welding.

15.3 Contractor to supply a fire watch for at a minimum of one (1) hour after any cutting or welding has taken place.

June 28, 2002

FIRE PROTECTION & SPRINKLER SYSTEM
TECHNICAL SPECIFICATIONS

For

CHARITON VALLEY BIOMASS PROJECT
FUEL RECEIVING AND PROCESSING FACILITY

at

OTTUMWA GENERATING STATION (Chillicothe, Iowa)

Chariton Valley Resource Conservation and Development, Inc.
Centerville, Iowa