



August 20, 2009

PO Box 156  
Lindsay, Nebraska 68644  
800-829-5300

<<Title>> <<FirstName>> <<LastName>>  
<<Company>>  
<<Address1>>  
<<City>> <<State>> <<PostalCode>>

Dear: <<FirstName>>

Attached is your Engineering Design Reference and Resource Guide to Land Application Systems. In this resource binder, you will find just about everything you need to know about the specifications and use of land application systems.

The information contained in this binder should assist you in easily matching the right kind and size of application system to your engineering project, including the specifications to include in your project planning and bid specification documents. You'll also find useful information to help support your recommendations and specification information on all the various system options that are available to meet the special needs of your waste water distribution project.

If you have any questions about Zimmatic land application systems, how they are used and how they can be adapted to meet the needs of your project, please feel free to contact our Application Engineering Team. We have more than 30 years of practical experience and would be happy to share our expertise with you. We can also put you in contact with Zimmatic field service people who can assist you on a more local basis. Please contact us at 800-829-5300 and ask for our Application Engineering Team. Also check out our website, [www.zimmatic.com](http://www.zimmatic.com).

For more than 30 years, Lindsay has been a world leader in the research, development, engineering and manufacturing of self-propelled automated center pivot and lateral move irrigation systems. Zimmatic system are successfully operating in more than 90 different countries irrigating more than 90 million acres. The manufacturing of this specialized equipment makes up more than 80% of our business which is one reason we enjoy a world-wide reputation for our quality materials and workmanship and have earned a reputation as being the most reliable and dependable irrigation system on the market. Our experience includes designing and implementing irrigation projects of all scales all across the world and in all kinds of operating environments.

Because we manufacture virtually our complete system, we monitor the quality that goes into our systems like few other manufacturers. Our manufacturing process is ISO 9001 certified and we stand behind our equipment with industry standard-setting warranties. This helps assure that the system you recommend in your project specifications will not only be the correct system to meet the needs of the project but will be one that continues to deliver reliable service for years after your project is successful turned over to your client.

Once again, should you have any questions regarding any of the information contained in your reference guide, please feel free to contact us.

Sincerely,

A handwritten signature in black ink, appearing to read "Rick Provan".

Rick Provan  
Zimmatic Product Manager





# Engineering Design Reference and Resource Guide

## Table of Contents

**Section 1 ..... Product Brochures**  
**Section 2 ..... History & Technical Information**  
**Section 3 ..... General Specifications**  
**Section 4 ..... Options Specifications**  
**Section 5 ..... Tables & Figures**  
**Section 6 ..... Bid Specifications Example**  
**Section 7 ..... Economic Comparisons**  
**Section 8 ..... Case Histories**

For more information on Zimmatic products, please visit the following:

**Zimmatic Home**

[www.zimmatic.com](http://www.zimmatic.com)

**Land Application/WasteWater**

[www.zimmatic.com/#!/Applications/LandApplicationWasteWater](http://www.zimmatic.com/#!/Applications/LandApplicationWasteWater)

**Center Pivot Systems**

[www.zimmatic.com/#!/Products/CenterPivotSystems/CenterPivot](http://www.zimmatic.com/#!/Products/CenterPivotSystems/CenterPivot)

**Maxfield Corners**

[www.zimmatic.com/#!/Products/CornerSystems/Maxfield](http://www.zimmatic.com/#!/Products/CornerSystems/Maxfield)

**Tracking Solutions**

[www.zimmatic.com/#!/Special Products/TrackingSolutions](http://www.zimmatic.com/#!/Special Products/TrackingSolutions)

**GrowSMART Technology Solutions**

[www.zimmatic.com/#!/Products/Products/Controls](http://www.zimmatic.com/#!/Products/Products/Controls)

## Zimmatic Land Application Systems



---

## *Notes*

---



# Engineering Design Reference and Resource Guide

## Product Brochures

Zimmatic Land Application Systems



---

*Notes*



Lindsay Corporation has received ISO9001 (International Standards Organization) certification. This certification is a series of standards establishing global requirements for quality management systems. Lindsay Corporation, adheres to the standards and procedures outlined in this program and is audited by both internal and external teams on a regular basis. This auditing process assures that we are not deviating from our quality system and are conforming to the standards.

---

## **INTRODUCTION**

The Irrigation Association is a group of irrigation equipment manufacturers, dealers and representatives, technical university personal and others who are organized to promote the proper use of irrigation equipment.

Individual members of the Center Pivot Commodity Group have experienced a rapidly increasing interest in the use of center pivot equipment for land treatment of municipal, industrial, food processing and agricultural wastewater. A wastewater engineering sub-committee was established to provide general equipment recommendations to assist consulting engineers and others in the design of center pivots for wastewater utilization or disposal.

## **LAND TREATMENT**

Land treatment is a process through which wastewater is applied to cropland using irrigation equipment. Wastewater can come from four different sources. These sources are food processing facilities, municipalities, agricultural waste (dairies, feedlots, poultry farms or hog farms) and some industrial facilities.

## **PURPOSE**

The purpose of the Engineering Design Reference and Resource Guide is to provide equipment recommendations for the design and installation of center pivot equipment to be used for the utilization or disposal of wastewater.

There are eight main sections to the Engineering Design Reference and Resource Guide. The eight are as follows: Product Brochures, History and Technical Information, General Specifications, Options Specifications, Tables and Figures, Bid Specifications Example, Economic Comparisons and Case Histories.

---

## **Section 1 - Product Brochures**

It provides an overview of all irrigation equipment sold by Lindsay Corporation. This section contains the following brochures:

- Zimmatic Land Application Systems
- Powerdrive Gearbox
- Zimmatic Tracking Solutions
- Irrigation Control
- FieldBOSS Control Panel
- FieldBASIC Control Panel
- Corrosion-Resistant Alternative Pipeline
- Maxfield Custom Corner System
- FieldNET
- Converting from Gravity Flow
- Nelson Water Application Solutions
- Senninger Low Drift Nozzle
- Senninger Lowering Application Intensity
- Senninger & Truss Rod Hose Slings
- Senninger i-Wob

## **Section 2 - History and Technical Information**

This section performs five objectives. First, it describes what Land Application is and the history behind its use. Second, it describes the history of the center pivot and Lindsay Corporation's experience in the irrigation business. Third, it describes important technical information with respect to soil characteristics, hydraulics, mechanics of the center pivot and design precautions when applying wastewater through a center pivot. Fourth, it describes installation and maintenance information. Fifth, it list examples of projects designed to apply wastewater.

## **Section 3 - General Specifications**

It contains specifications for preparing a bid to include a center pivot. These specifications describe general specifications that are part of all Lindsay Corporation's center pivots. The following are a few examples of options in the General Specifications section. The consultant engineer may choose from these options. For example, one option allows the engineer to choose span length and pipe diameter. The engineer will choose the right span length to allow the center pivot to fit the irrigated area. Pipe diameter will depend on flow rate, pumping cost, yearly hours of operation, span cost and pressure requirements.

---

A second option is a choice of motor speeds for each tower. This choice is between a 43 rpm motor and an 86 rpm motor. The motor speed is determined by the time frame that the pivot needs to go around the field. A third option is a choice of tire size. Tire size selection depends on the soil type and desired machine speed. A fourth option is a choice between two master control panels. One is a programmable panel and the other is not. In addition to these options, there are other options available.

#### **Section 4 - Options Specifications**

This section addresses the four following wastewater sources: food processing waste, municipality waste, agricultural waste or industrial waste. It addresses options particular to the wastewater source and the facility that produces it or required to dispose of it. The consultant engineer can choose what options they need in the design bid.

#### **Section 5 - Tables and Figures**

This section explains to the consultant engineer how the center pivot is constructed. It also provides tables useful for design information.

#### **Section 6 - Bid Specifications Example**

This section contains an example of a center pivot design bid. This will assist the consultant engineer in providing a center pivot design bid.

#### **Section 7 - Economic Comparisons**

This section provides economic comparisons of the different types of irrigation systems produced by Lindsay Corporation.

#### **Section 8 - Case Histories**

This section contains actual case histories from customers. Some of these case histories are projects designed for applying wastewater from food processing facilities, municipalities and livestock farms.

### **CONTACTS**

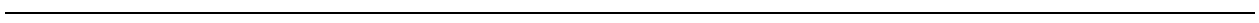
Please contact Lindsay Corporation's Application Engineering Team for additional information. Please feel free to use the toll free number 1-800-829-5300



# Engineering Design Reference and Resource Guide

## History and Technical Information

Zimmatic Land Application Systems



---

*Notes*

---

# ***Table of Contents***

## **History and Technical Information**

<b>History of Land Treatment .....</b>	<b>2-5</b>
<b>History of the Center Pivot.....</b>	<b>2-6</b>
<b>Design Information .....</b>	<b>2-8</b>
Site Characteristics .....	2-8
Hydraulics .....	2-9
Mechanical .....	2-14
Design and Operation Considerations .....	2-16
<b>Installation .....</b>	<b>2-18</b>
Pivot Anchor.....	2-18
Equipment Erection.....	2-18
Electrical Service.....	2-18
Training and Maintenance Personnel .....	2-18
<b>Project List .....</b>	<b>2-19</b>
Food Processing .....	2-19
Municipal .....	2-20
Agricultural .....	2-21

---

*Notes*

---

## THE HISTORY OF LAND TREATMENT

### LAND TREATMENT: THE RESOURCEFUL ALTERNATIVE

The principals of land treatment date back at least to early Athens when some of the first applications were used. In the U.S., land treatment has been serving cities and surrounding farms since the 1800's.

In the 1970's, the U.S. government began exploring the advantages of land treatment in a demonstration project for Muskegon County, Michigan. Along with contributing to significant increases in crop production, the system demonstrated the capability of the crop/soil ecosystem as a method of achieving high levels of wastewater reuse and renovation.

More recently, as a result of Muskegon and other studies, the land treatment concept has become widely accepted as a cost-effective method of accomplishing high levels of waste water treatment. A policy directive of the U.S. Environmental Protection Agency stated:

“Land treatment is capable of achieving removal efficiencies comparable to the best available advanced treatment technologies while achieving additional benefits.”

Aside from the obvious advantage of conserving resources--mainly precious water supplies as well as the raw materials and energy used to produce equivalent quantities of fertilizer--land treatment promises significant advantages in total life cycle costs, especially with respect to the operation and maintenance of treatment facilities. Unlike the complex advanced wastewater treatment systems, land treatment relies on relatively simple, primary or combination primary-secondary facilities, with the growing crop and soil system serving as the “tertiary plant.”

Working with the land treatment concept and contributing to its efficiencies are today's advanced, proven and highly reliable irrigation systems...primarily the center pivot.

These irrigation systems are fully automated and, once started by the operator, require only minimal attention. Center pivots are capable of distributing various types of wastewater uniformly across the site at a predetermined rate. Years of experience in agricultural crop irrigation from wells, streams and ponds have led to many improvements in design, all contributing to proven performance and acceptance on a wide variety of soil, crop, slope and other site conditions.

---

## THE HISTORY OF THE CENTER PIVOT

Center pivot systems were first patented in 1952. This type of system consisted of a sprinkler lateral that moved in a circle about an anchored pivot point.

In the 1950's:

- Lindsay Corporation began producing agricultural equipment.
- The ability to save energy and labor, found rapid acceptance by growers.

In the 1960's:

- Lindsay Corporation introduced of the first Zimmatic Electric Drive Center Pivot System.
- Other innovations included the heavy duty enclosed wheel gearbox, split coupler and uni-knuckle tower joints.
- These innovations allowed the Zimmatic center pivot to travel uneven and rolling terrain. As a result irrigators named it the "hill climber."

In the 1970's:

- Lindsay Corporation was awarded the U.S. Patent for the Uni-Knuckle Joint.
- The first long spans were manufactured to reduce the number of towers and wheel tracks required and to minimize wheel tracks.
- The external collector ring was developed during this decade. (Lindsay still holds patent)
- Low pressure systems were introduced to meet spiraling energy costs.
- Lateral move systems were introduced.
- Mobile pivots made it practical to irrigate multiple fields with a single system.

In the 1980's:

- Lindsay Corporation developed the corner system to extend pivot coverage.
- The Remote Monitor Alarm and Control (R-MAC) was introduced to control center pivots remotely by telephone or radio.
- A big change occurred in the center pivot structure design with the introduction of the Generation II pivots.
- This change was developed with the assistance of CAD (Computer Aided Design), CAM (Computer Aided Manufacturing) and finite element analysis. The design allowed for commonality of parts.
- A new spur gear center drive design was introduced to increase efficiency and lower energy requirements.

---

In the 1990's:

- Lindsay Corporation introduced the Automated Irrigation Management System (AIMS).
- This saved labor and added precision to the irrigation process.
- The AIMS Telemetry Network naturally followed. This technology allowed users to monitor program and control single or multiple systems remotely.
- Lindsay Corporation also developed the formed outlet.
- The formed outlet is manufactured through a process, by which, the outlet is formed from the pipe material.
- The Pendulum Linkage was produced to connect the steerable corner to the main machine.

In the 2000's:

- Lindsay pioneered the MAXField Continuous Move Corner with pulsating sprinklers obtaining uniform water application on various swing angle rates.
- Telemetry also achieved optimal coverage and control thru the FieldBOSS and FieldNET systems.
- Communication through the internet was introduced to control and monitor pivots.
- Floatation was increased and wheel tracks reduced with the technologies advance of Z-trax.

In the 21st century, Lindsay Corporation will continue to develop increasingly sophisticated use of electronics in time saving remote control, monitoring, record keeping and planning. Along with this, engineering will steadily increase the ability to determine crop needs for precision application of water and nutrients.

As one of the world's largest manufacturers of center pivots and other irrigation equipment, Lindsay Corporation has years of experience assisting communities, industries, farms, food processors and their consultant engineers in planning effective land treatment systems.

Lindsay Corporation has recognized the benefits of land treatment. In response, it has created the "Designed Resource and Reference Guide" manual.

---

## DESIGN INFORMATION

### A. Site Characteristics

#### 1. Soil Characteristics

The characteristics of the soils are probably the largest single factor in the overall design of a wastewater irrigation project as well as in the design of the specific application equipment. Of particular importance, with respect to the application equipment, is the soil infiltration rate (the rate at which water will enter the soil) and the soil permeability (the rate at which water will move through the soil profile), which affect the distribution pattern selected. In addition, the soil particle size distribution affects tire size selection with respect to traction and flotation requirements.

A general guideline is in Table 1. for soil water intake rates.

Table 1.

<b>Water Intake Rates</b>	
	Water Intake Rates (in/hr)
Sands	1.0 - 2.0
Sandy Loams	0.5 - 1.0
Fine Sandy Loams	0.3 - 0.6
Silt Loams	0.05 - 0.3
Clays	0.05 - 0.6

---

With respect to particle size distribution, the U.S. Department of Agriculture has defined soil particles, which is found in Table 2..

Table 2.

<b>Soil Particle Size</b>	
	Particle Diameter (mm)
Very Coarse Sand	1 - 2
Coarse Sand	0.5 - 1
Medium Sand	0.25 - 0.5
Fine Sand	0.10 - 0.25
Very Fine Sand	0.05 - 0.10
Silt	0.002 - 0.05
Clay	Less Than - 0.002

## 2. Topography

Center pivot equipment is capable of negotiating relatively rough terrain with some manufacturers warranting equipment on slopes in excess of 15%. Wastewater irrigation may be satisfactorily accomplished on relatively steep slopes, especially where full cover crops are grown, with the following two conditions. The first condition is when wastewater application is used only to satisfy crop water requirements. The second condition is when good system management is employed to alleviate runoff.

## **B. Hydraulic**

### 1. Flow Rate

The design flow rate to center pivot equipment is designed according to primarily crops grown, soil characteristics, climate and area irrigated.

### 2. Application Efficiency

Application efficiency is that percentage of the total water pumped, which reaches the ground or plant surfaces. This efficiency is primarily dependent upon climatological factors such as ambient temperature, relative humidity, wind velocity, direction, etc. Application efficiency is also affected by the selected application depth. In general, an application efficiency of approximately 90% can normally be expected, assuming at least 1" of water is applied.

---

### 3. Distribution Pattern

Essentially, four particular techniques are available to distribute wastewater from the center pivot lateral pipeline to the soil surface. The distribution pattern selection will be determined by soil type and conditions, field topography, quantity and size of solids in the wastewater, aerosol production, relative tendency of spray to drift from the spray site and other possible factors. Figure 1. is a pictorial representation of the four distribution patterns available. An explanation of each follows:

#### a. Fixed Spacing, Variable Size Sprinklers

This distribution pattern is characterized by variable sized impact sprinklers evenly spaced along the length of the center pivot lateral pipeline. This alternative provides the widest pattern and thus produces the lowest application rate. For this reason, it is the most versatile of the distribution patterns with respect to soil and topography. It does, however, require a slightly higher operating pressure than the variable spacing, medium size sprinkler alternative.

#### b. Variable Spacing, Medium Size Sprinklers

This distribution pattern is characterized by the use of medium size impact sprinklers spaced increasingly closer from the pivot point outward along the center pivot lateral pipeline. Since medium size sprinklers are used, smaller water droplets are produced, which decreases possible soil compaction and lessens potential damage to emerging seedlings.

#### c. Revolving, Moving or Wobbling Plates

This distribution pattern is characterized by the use of a fixed orifice nozzle with a revolving or moving wobbling plate. Nozzles increase in orifice size and are spaced closer outward from the pivot point along the center pivot lateral pipeline. The movable plate will have a wider pattern than stationary plates. This allows for a lower application rate and so they can be used on steeper slopes and on soils with lower intake rates. The sprinklers may be spaced wider apart. Again, they may operate at lower pressures so pumping cost are lower. Certain plates produce small droplets and are gentler on soil and emerging seedlings. Other types of revolving and moving wobbling plates fill in the wetted diameter better than stationary plates. These sprinklers are normally placed on drops.

Drops are a hard or soft hose coming off the main pipeline towards the ground. Drops are used to get the sprinkler head closer to the ground. The use of drops is advantageous, they reduce the droplet impact on the soil and conserve water loss do to evaporation during vertical air travel time.

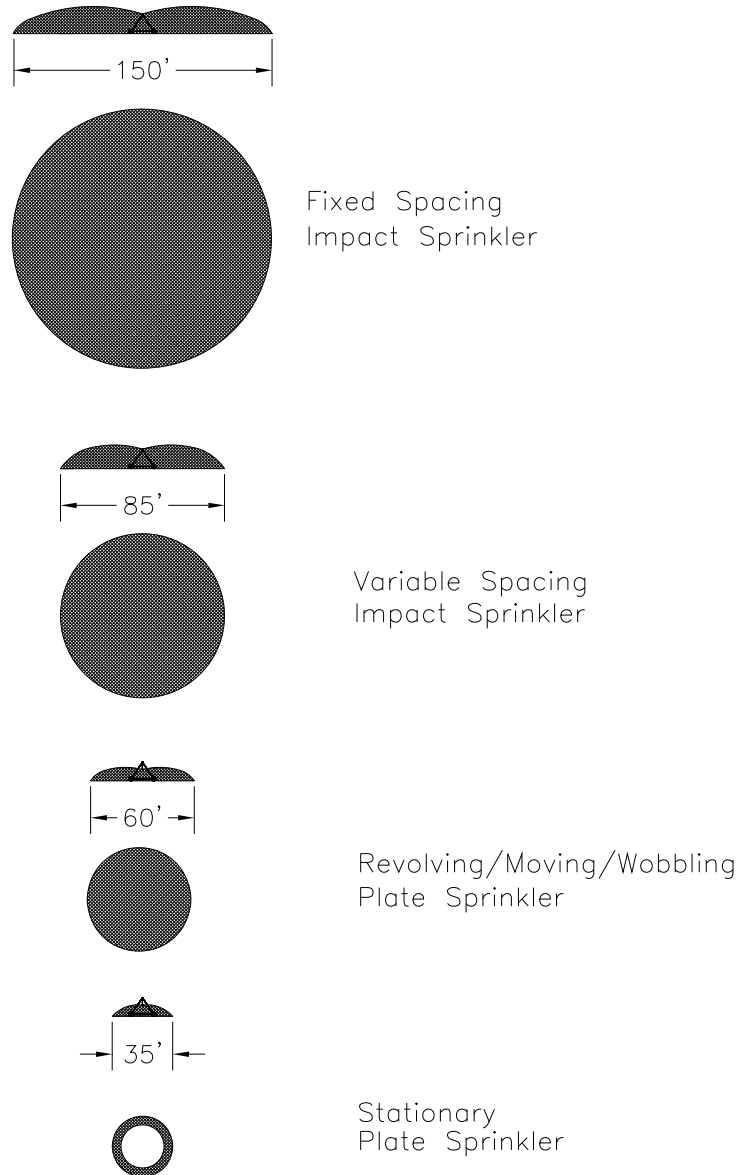
#### d. Stationary Plates

This distribution pattern is characterized by the use of fixed orifice nozzle and splash deflector-type spray plates. Nozzles increase in orifice size and are spaced closer outward from the pivot point along the center pivot lateral pipeline. Since this pattern produces higher application rates, it is not as suitable for low intake rate soils or steep


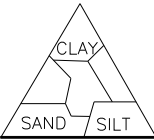

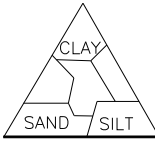

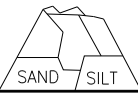




---

slope conditions. Due to the low pressure requirements, this pattern requires the least power for pumping. It also produces the least soil compaction and the least damage to emerging seedlings because it produces smaller droplets and the droplets have less energy. When placed on drops there will be a water savings of 1% for every foot of drop.

**Figure 1: Distribution Patterns**

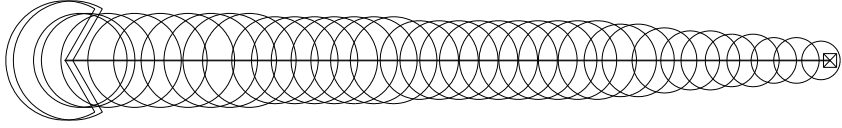
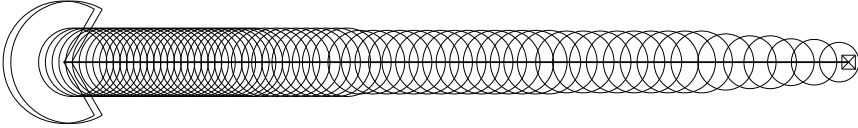
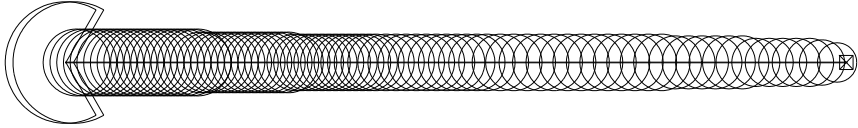
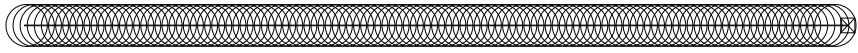



**Figure 2: Water Distribution Package Application Information**

Sprinkler Spacing	Normal Spacing	Distance of Coverage	Minimum End Pressure * (PSI)	Relative Droplet Size	Soil Type	Wind Effects	Evaporation	Runoff Potential
Fixed (Standard)	40'	140-160	45			Med/High	Med/High	Low
Variable Medium Pressure	33', 25' 16', 8'	90-100	35-40			Med/High	Med	Med
Low Pressure	25', 16' 8'	60-80	20			Low/Med	Low	Med High
Spray 360°	8'	30-40				Low	Low	High
180°	8'	15-20				Low	Low	High

\* Minimum Pressure Selected for a particular situation should take maximum field elevation sprinkler/end gun nozzle sizes and soil/crop conditions into account.

**Figure 3: Water Distribution Packages Diagram**

<p><b>Standard Spacing</b></p> 	<p>Maximum Diameter (Feet)</p>	<p>Relative Droplet Size</p>
<p><b>Variable Spacing</b></p> 	<p>90-100</p>	<p>Medium</p>
<p><b>Low Pressure Impact Spacing</b></p> 	<p>60-80</p>	<p>Large</p>
<p><b>Full-Circle Low Pressure Spacing</b></p> 	<p>30-40</p>	<p>Small</p>
<p><b>Half-Circle Low Pressure Spacing</b></p> 	<p>15-20</p>	<p>Small</p>

\*\*Droplet size will change with pressure. Large droplets increase the possibility of surface sealing. Small droplets have a greater tendency to be affected by wind.

---

#### 4. Coefficient of Uniformity (C.U.)

Christiansen developed the accepted method for determining the C.U. for center pivot equipment. The standard for determining this method is ASAE S436.1. The conditions under which this determination must be made are: (1) the field must be nearly flat in the test area; (2) the data should be collected when the wind is blowing perpendicular to the center pivot lateral pipeline; (3) increased test duplication is required as wind velocity increases. If the wind is over 15 m.p.h., the test should not be attempted.

A C.U. test should not be required and may not be desirable as a pre-condition to acceptance of the equipment. This is because the C.U. is directly related to pump operation, condition of the pivot lateral pipe, and the design and manufacturing variations between individual impact sprinklers or spray nozzles. After approximately one year's use, the system will achieve a C.U. of at least 80%, which all manufacturers are capable of achieving. Most manufacturers will supply computerized nozzle selection charts upon request.

### C. Mechanical

#### 1. Structural Components

The design of all structural components should be in accordance with the latest specifications issued by the American Institute of Steel Construction (AISC) and be designed to accommodate a 90 m.p.h. wind load directed perpendicular to the center pivot lateral pipeline with a 1.1 safety factor.

The center pivot pipeline consists of the water supply pipeline that is supported by a rod and angle truss structure. The center pivot pipeline and structure suspended are moved by one or more mobile support structures or towers. Several tracking options are available to be mounted on the towers, which may be located from 80' to 200' apart along the center pivot pipeline. The total center pivot lateral pipeline length (radius) may vary from under 100' to as long as approximately 2600' with the most common system lengths for agricultural being approximately 1300'.

The ground clearance of the pipeline and support structure for center pivot equipment is approximately 9.5 feet and varies by span length. This ground clearance allows for equipment flexibility to irrigate relatively high growing crops.

Corrosion protection can be one of the following: hot-dip galvanized pipe according to the ASTM 123 standard, stainless steel pipeline, Polylined galvanized lateral pipeline. Effluent quality and the design equipment service life determine the most desirable method of corrosion protection.

---

## 2. Drive Train

Several different methods and configurations are used to power this equipment. Center pivot equipment may be hydraulically powered by water, oil or air, or may be electrically driven. Electric drive center pivot equipment is presently the most widely accepted and used. The drive method should be selected on the basis of slope, soil conditions and required equipment flexibility to meet the desired needs.

When rubber tires are used, they must be selected based on soil conditions at the proposed waste utilization site. One readily measured soil characteristic, which is used to determine the contact area required for support of the unit, is the relative quantity of fine material present in the soil. Table 3. provides a guideline on allowable soil contact pressure based upon the percentage of fine material in the soil, where fine material is defined as any material that passes a 200 mesh sieve.

Table 3.

<b>Allowable Soil Contact Pressure</b>	
<b>% Fines</b>	<b>Contact Pressure (psi)</b>
Less than 20	30
20-30	25
30-40	16
Less than 50	12

Selection of tires that exceed the recommended contact pressure may result in wheel tracking problems. Slightly lower recommended allowable contact pressures may be advisable for pivots operating on rough terrain in soils with a high percentage of fines. See Table 3. in the Tables and Figures section for contact pressure of each center pivot lateral span length, center pivot lateral pipeline diameter and tire size.

---

### 3. Electrical

All electrical components on center pivot equipment should conform to the latest issue of the National Electrical Code, Article 675.

All electrically driven center pivots should also meet the American Society of Agricultural Engineers (ASAE) Standard S362.2, "Wiring and Equipment for Electrically Driven or Controlled Irrigation Machines." It is recommended that only electric motors designed specifically for use on center pivot irrigation equipment be used.

## D. Design and Operation Considerations

1. The primary goal of land application is two fold:
  - a. To dispose of wastewater.
  - b. To supply nutrients to the crop.
2. Wastewater has different nutrient and pollutant types and amounts that need to be considered.
  - a. Wastewater contains valuable nutrients such as nitrogen, phosphorus, potassium and other trace elements. It is important to know how much of each is in the wastewater. It is also important to know what the crop requires. The application of wastewater should occur when the crop requires the available nutrients. This ensures the most efficient use of the wastewater. It also prevents unnecessary pollution. Be sure to follow local, state and federal agencies' recommendations concerning nutrient build-up.
  - b. "Certain trace elements should be monitored so that their accumulation in the soil does not exceed threshold limits, thus preventing toxicity to humans, animals, and/or plants."<sup>1</sup> When wastewater contains heavy metals, "a qualified engineer, crop specialist or soil scientist should be consulted on these systems."<sup>2</sup>
  - c. Salt problems could be a concern in certain areas, especially in drier climates. Be sure to monitor salt concentrations in the wastewater and soil. "Consult a qualified engineer, crop consultant or soil scientist to determine if loading rates will result in salinity problems."<sup>3</sup>
  - d. "All effluent from human sources should be disinfected before being applied by irrigation."<sup>4</sup> There are certain methods to disinfect wastewater. Please consult qualified engineers for assistance. Also follow federal, state and local guidelines concerning pathogens in wastewater.

---

1. Garrick, J. Chris. 1999. Waste Water? Not! Irrigation Journal, January/February: pp. 8,9.

2. Scherer, Thomas F., W. Kranz, D. Pfof, H. Werner, J.A. Wright and C.D. Yonts; Sprinkler Irrigation Systems; MidWest Plan Service; First Edition; Iowa State University; Ames, IA; 1999; p. 169.

3. Scherer, Thomas F., W. Kranz, D. Pfof, H. Werner, J.A. Wright and C.D. Yonts; Sprinkler Irrigation Systems; MidWest Plan Service; First Edition; Iowa State University; Ames, IA; 1999; p. 169.

4. Scherer, Thomas F., W. Kranz, D. Pfof, H. Werner, J.A. Wright and C.D. Yonts; Sprinkler Irrigation Systems; MidWest Plan Service; First Edition; Iowa State University; Ames, IA; 1999; p. 169.

- 
- e. If odor is a problem, use sprinklers on drops or low trajectory sprinklers, sprinklers with wind resistant streams and low pressure to reduce odors. Make sure to apply wastewater at the proper time and proper environmental conditions to decrease odor problems. "Check local and state regulations regarding buffer distances from wells, drain wells, water supplies, residences, property boundaries, etc."<sup>5</sup>
  3. It is the responsibility of the operator, owner and consultant engineer to find out the federal, state and local guidelines pertaining to irrigating with wastewater and to following those guidelines. Some examples may refer to the following:
    - a. Wastewater should be retained on the property where it is generated.
    - b. Wastewater should be applied at rates which meet published guidelines.
    - c. Appropriate system design will prevent runoff of wastewater.
  4. Drift can be a concern in some areas. This can be solved by using sprinklers on drops, especially at the end spans of the center pivot lateral pipeline. Another option is to provide a buffer zone around the edge of the property on which the wastewater is applied.
  5. "The system should be flushed after each irrigation to prevent the growth of algae, bacteria and noxious odors. Disinfection is recommended."<sup>6</sup>
  6. "The standard for preventing all nozzle plugging of sprinklers entails filtering to 1/7th of the size of the smallest orifice."<sup>7</sup> If the percent solids are over 4%, big guns are preferred.
  7. Make sure the application of water does not exceed the hydraulic loading of the soil.
  8. A stainless steel pipeline or inserted poly pipe may be recommended if the wastewater is corrosive.
  9. If material buildup on the pivot components or freezing water is a concern, use 180° directional sprinklers or sprinklers on drops.

---

5. Scherer, Thomas F., W. Kranz, D. Pfof, H. Werner, J.A. Wright and C.D. Yonts; Sprinkler Irrigation Systems; MidWest Plan Service; First Edition; Iowa State University; Ames, IA; 1999; p. 169.

6. Garrick, J. Chris. 1999. Waste Water? Not! Irrigation Journal, January/February: p. 9.

7. Nelson Irrigation Corporation. 1999. Pivot Wastewater Application.

---

## **INSTALLATION**

### **A. Pivot Anchor**

Center pivot irrigation systems are normally anchored to a concrete foundation. This concrete pivot anchor should be based upon recommendations of the center pivot manufacturer and should conform to the American Concrete Institute (ACI) specifications. Although the pivot anchor varies between manufacturers, the concrete requirement normally ranges from 4 to 6 cubic yards.

### **B. Equipment Erection**

The installation and erection of center pivot equipment should be done by or under the supervision of authorized manufacturer's personnel to assure strict compliance with the manufacturer's recommendations.

### **C. Electrical Service**

Electrical service to center pivot equipment should meet the American Society of Agricultural Engineers (ASAE) Standard S397.2 "Electrical Services and Equipment for Irrigation," which are standards approved by the Irrigation Association. National Electric Code requirements should also be met. It is a good practice to check for other state and local electrical codes.

### **D. Training of Maintenance Personnel**

The design for land treatment systems, like other systems, should include scheduled maintenance time. To accomplish this scheduled maintenance, as well as a large portion, if not all, of the unscheduled maintenance and training of maintenance personnel is required. It is recommended that maintenance training be conducted by qualified manufacturer authorized personnel. Operation and maintenance manuals, along with any other pertinent materials, should be provided to the person(s) in charge of equipment maintenance.

---

## PROJECT LIST

### A. Food Processing

Table 4.

Project	Location	Type of Equipment	Qty.
Eastern Shores Seafood	Delaware	Center Pivot	11
Townsend's Inc.	Delaware	Center Pivot	6
S.E. Paper Co.	Georgia	Center Pivot	5
Avonmore West	Idaho	Center Pivot	2
Simplot Potatoes	Idaho	Center Pivot	1
Mansfield & Sons	Maryland	Center Pivot	1
Ravenna Cheese	Nebraska	Center Pivot	1
IBP	Nebraska	Center Pivot	9
Poultry Processing	North Carolina	Lateral Move	2
Food Processing	Oregon	Center Pivot	1
Campbell Food	Texas	Center Pivot	1
Excel Packing Co.	Texas	Center Pivot	2
Gosnea Foods	Utah	Center Pivot	1
Basic American Foods	Washington	Center Pivot	4
Carnation Foods	Washington	Center Pivot	4
McCain Foods	Washington	Center Pivot	2
Hog Processing	Canada	Center Pivot	1

## B. Municipal

Table 5.

Project	Location	Type of Equipment	Qty.
Inland Bays Project	Deleware		
Sussex County	Deleware		
Wolfe Creek	Deleware		
Immokalee Project	Florida	Center Pivot	3
Punta Gorda	Florida	Center Pivot	12
Hayden Lake	Idaho	Center Pivot	3
Idaho Falls	Idaho	Center Pivot	2
Pocatello	Idaho	Center Pivot	3
Bourbon	Indiana	Center Pivot	1
Ulysses	Kansas	Center Pivot	1
Coldwater	Michigan	Center Pivot	1
Humphrey	Nebraska	Center Pivot	1
Guymon	Oklahoma	Center Pivot	6
Goodwell	Oklahoma	Center Pivot	1
Hooker	Oklahoma	Center Pivot	1
Tyronre	Oklahoma	Center Pivot	1
Medford	Oklahoma	Center Pivot	1
Apache	Oklahoma	Center Pivot	1
Mitchell	South Dakota	Center Pivot	9
Abernathy	Texas	Center Pivot	2
Amarillo	Texas	Center Pivot	2
Canyon	Texas	Center Pivot	1
Dept. of Corrections	Texas	Center Pivot	4
Lubbock	Texas	Center Pivot	46
San Angelo	Texas	Center Pivot	29
Slaton	Texas	Center Pivot	2
S.W. Public Service	Texas	Center Pivot	1
Davenport	Washington	Center Pivot	1
Diamond Lake	Washington	Center Pivot	1
Loon Lake	Washington	Center Pivot	1
Sunnyside	Washington	Lateral Move	1
Dayton	Canada	Center Pivot	1
Lloyd Minister	Canada	Center Pivot	1
Moose Jaw	Canada	Center Pivot	1
Swift Current	Canada	Center Pivot	1
Whitewood	Canada	Center Pivot	1

---

## C. Agricultural Waste

Table 6.

Project	Location	Type of Equipment	Qty.
Lane County Feeders	Kansas	Center Pivot	3
Hog Confinement	Nebraska	Center Pivot	1
Pig Improvement Corp.	Oklahoma	Center Pivot	33
Cederwood Dairy	Texas	Center Pivot	1
Devries Dairy	Texas	Center Pivot	1
Lueck Dairy	Texas	Center Pivot	1
J&J Dairy	Texas	Center Pivot	1
Lloyd Dairy	Texas	Center Pivot	1
Shenk Dairy	Texas	Center Pivot	2
Steinberger Dairy	Texas	Center Pivot	1
Tex-AZ Dairy	Texas	Center Pivot	2
Tex-Stein Dairy	Texas	Center Pivot	1
Utter-Delight Dairy	Texas	Center Pivot	2
Allan Hatchery	Virginia	Center Pivot	4
Ed Driesen - Dairy	Washington	Center Pivot	1
Jo DeHoog - Dairy	Washington	Center Pivot	1
Don Whitehead	Canada	Center Pivot	1
Hog Confinement	Canada	Center Pivot	1

---

*Notes*



## Engineering Design Reference and Resource Guide

### General Specifications

### Zimmatic Land Application Systems



---

## *Notes*

---

# Table of Contents

## GENERAL SPECIFICATIONS

<b>Summary of Specifications .....</b>	<b>3-5</b>
<b>Detailed Center Pivot Specification .....</b>	<b>3-6</b>
Structural Design .....	3-6
Span Couplers and Joints .....	3-11
Wheel Gear Boxes for Self Propelled Towers .....	3-13
Drive Shafts and Aluminum Couplers .....	3-15
Center Drive Gear Boxes and Electrical Motors .....	3-15
Wheel Sets .....	3-17
General Electrical Specifications .....	3-18
Nozzling Design .....	3-29

---

*Notes*

---

## General Specifications

### Summary of Specifications

1. Lindsay Corporation and \_\_\_\_\_(dealer name) will work with you, the customer and the consultant engineer, to supply a Zimmatic center pivot to apply wastewater from municipalities, industries, food processing operations and agricultural operations through a process called Land Treatment. The center pivot design construction will follow a list of specifications.
2. The design of the Zimmatic center pivot will be built in accordance to the specifications listed in the following General Specifications section. The structure will be constructed of steel with all members being galvanized with the exception of available options. The pivot point contains the industry's only external collector ring to prevent obstructions in the pivot ell and head assembly, causing pressure loss. The joints will have an aluminum split coupler with an inner boot. This allows for the boot to be readily changeable. The towers shall have a self propelled drive train which operates from a Lindsay spur gear center drive. All wheels shall have pneumatic rubber tires and steel galvanized rims. The center pivot is controlled from three phase electric power at the pivot point and at each tower. This allows for flexibility in controlling the speed and it easily lends the center pivot to be programmable. A wide range of sprinklers are available to fit the application requirements of the wastewater. An option called FieldNet is available to control multiple center pivots remotely from a cellular telephone, radio or a centrally based personal computer. This option also allows records to be kept in regards to the amount of wastewater applied by the pivots. Stainless steel pivot lateral pipeline, poly insert galvanized lateral pipeline are options to allow for transportation and irrigation of corrosive wastewater. When applying wastewater with large suspended particles, large volume guns should be used.
3. The following pages reflect the design specifications for Zimmatic Center Pivot Systems. Additionally, Lindsay Corporation makes Lateral Moves and Corner Systems. Please call Lindsay Corporation's Application Engineering Team at 1-800-829-5300 for additional information.

## Detailed Center Pivot Specification

### Structural Design

#### A. Center Pivot General Features

The center pivot system provided shall have the following general features:

1. Under truss design
2. Span lateral pipeline (Lengths are shown in Figure 3.1, which is below in the Tables and Figures section shows the dimensions of each span type.)

Figure 3.1.

Pipe O.D.	Span Length										
	*113'	114'	*135'	136'	*157'	160'	168'	*179'	180'	186' 8"	*201'
10"	X		X								
8"	X	X	X	X	X	X	X	X	X	X	
6-5/8"	X	X	X	X	X	X	X	X	X	X	X
5-9/16"	X	X	X	X	X	X	X	X	X	X	X

\*Standard span lengths

3. Overhang Lengths: 5-9/16" - 11', 22', 33', 44', 55', 66', and 88' (Dimensions are shown in Table 2. of the Tables and Figures section.)
4. An approximate outlet spacing of 30" and/or 90" on all pipe
5. Electrically powered and controlled towers
6. Spans supported on self propelled towers

#### B. Pivot Point Structures

There are two options of pivot point structures. These include the heavy duty pivot point and the standard duty pivot point.

1. OPTION A: Heavy Duty Pivot Point Structure.

The heavy duty pivot point structure will be constructed of four legs. Each leg shall be 4" x 4" x 3/8" angle iron and be 11' long. Each side shall have three horizontal ties with the angle iron having the dimensions of 2" x 2" x 3/16". The top tie on each side shall be 1-1/2" x 1-1/2" x 1/8" angle iron. Rolled formed angle iron is unacceptable. Non-tow anchor weldments are used on non-towed structures for the footings. The footings must be bolted to the outside of the pivot point legs and not to the inside of the legs. The base of the pivot point shall measure 10'-1-3/4" x 10'-1-3/4" on the outside of the pivot legs. Smaller dimensions will not be acceptable.

---

The heavy duty pivot point structure will be used on longer machines or machines that operate on hilly terrain. (See Figure 5. of the Tables and Figures section.)

2. OPTION B: Standard Duty Pivot Point Structure.

The standard duty pivot point structure will be constructed of four legs. Each leg shall be 4" x 4" x 1/4" angle iron and be 11' long. One side shall have three horizontal ties with the angle iron having the dimensions of 2" x 2" x 3/16". The top tie on that same side shall be 1-1/2" x 1-1/2" x 1-8". The other three sides shall each have one piece of angle iron with the dimensions of 2" x 2" x 3/16". This tie shall have the length of 71-11/16". Rolled formed angle iron is unacceptable. Non-tow anchor weldments are used on non-towed structures for the footings. The footings must be bolted to the outside of the pivot point legs and not to the inside of the legs. The base of the pivot point shall measure 10'-1-3/4" x 10'-1-3/4" on the outside of the pivot legs. Smaller dimensions will not be acceptable. The standard duty pivot point structure will be used on short center pivots.

3. OPTION C: Compact Pivot Point Structure

The compact pivot point structure will be constructed of four legs. Each leg shall be 4" x 4" x 1/4" angle iron and be 10' long. One side shall have three horizontal ties with the angle iron having the dimensions of 2" x 2" x 3/16". The top tie on that same side shall be 1-1/2" x 1-1/2" x 1-8". The other three sides shall each have one piece of angle iron with the dimensions of 2" x 2" x 3/16". This tie shall have the length of 55 1/2". Rolled formed angle iron is unacceptable. Non-tow anchor weldments are used on non-towed structures for the footings. The footings must be bolted to the outside of the pivot point legs and not to the inside of the legs. The base of the pivot point shall measure 7'-1/2" x 7'-1/2" on the outside of the pivot legs. Smaller dimensions will not be acceptable. The standard duty pivot point structure will be used on short center pivots.

C. Pivot Elbows, Pivot Heads, Pivot Risers and Pivot Ell Joints

There are different options of pivot elbows, pivot heads, pivot risers and pivot ell joints.

1. OPTION A: 8" Elbow, Head and Riser with an 8", a 6-5/8" or a 5-9/16" Pivot Ell Joint

The 90° rotating elbow will be constructed of 8" O.D. cast iron and be welded on the upper side to either an 8" O.D. (11 gauge), a 6-5/8" O.D. (11 gauge) or a 5-9/16" O. D. (12 gauge) pivot ell joint. The pivot ell joint must be adaptable to the pipe diameter of the first span. The cast iron elbow will be welded on the lower side to a steel pivot ell pipe all galvanized. The steel pivot ell pipe shall be 8" O.D., 11 gauge (0.107" wall) tubing with a length of 41-5/8". The pivot ell pipe will be inserted into a pivot head. The pivot head shall be 8-5/8" O.D. with a 0.219" wall thickness and it shall be 35-7/8" long. This pivot head shall have four pieces of angle iron welded at an angle of 33° from parallel to the pivot head. The angle iron shall be 31-1/4" long. A welded gusset shall brace each angle iron to the pivot head. The riser shall be constructed of galvanized 8" O.D., 11 gauge (0.107" wall) tubing. There shall be an 8" female coupler welded to the top of the riser. The riser and coupler shall be 75-3/4" long. There must be an 8" O.D. 90° steel elbow on the bottom of the riser.

---

The pivot point gasket shall be round with a triple lip seal and readily changeable.

There will be four 2" x 3/8" flat straps to stabilize the pivot riser. (See Figure 5. of the Tables and Figures section.)

2. OPTION B: 10" Elbow, Head and Riser with a 10" Pivot Ell Joint

The 10" pivot point structures will use 10" cast iron O.D. for the elbows and 10" O.D. tubing for the riser. The upper side of the 10" cast iron elbow will be welded to a 10" O.D. (11 gauge) pivot ell joint. The pivot ell joint must be adaptable to a 10" O.D. pivot pipe. The lower side of the 10" cast iron elbow must be welded to a pivot ell pipe. The pivot ell pipe shall be 10" O.D., 10 gauge tubing with a length of 30-1/2". The pivot ell pipe shall be inserted into a pivot head. The pivot head shall have a 10-1/4" minimum I.D. and it shall be 23-7/8" long. The pivot head shall have four pieces angle iron welded at 33° from parallel to the pivot head. The angle iron shall be 28-3/8" long. A welded gusset shall brace each angle iron to the pivot head. The riser shall be constructed of galvanized 10" O.D., 12 gauge tubing. A female coupler shall be welded to the top of the riser. The riser and coupler shall be approximately 72-1/4" long. There must be a 10" elbow welded to the bottom of the riser.

The pivot point gasket shall be round with a triple lip seal and readily changeable.

There will be four 2" x 3/8" flat straps to stabilize the pivot riser.

D. Center Pivot Lateral Pipeline

1) Generation II Heavy Wall Pipe

The center pivot lateral pipeline sizes will be 6-5/8" O.D., with an 11 gauge (0.107" min. (2.72 mm)) wall thickness (min.), 5-9/16" O.D., with a 12 gauge (0.097" min. (2.46 mm)) wall thickness (min.), 8" O.D., with an 11 gauge (0.107" min. (2.72 mm)) wall thickness (min.) and 10" O.D., with an 11 gauge (0.107" min. (2.44 mm)) wall thickness (min.). Piping will be formed from A1S1SAE 1010 coil sheet or approved equal. (See Figures 1., 2. and 3. of the Tables and Figures section.)

The center pivot lateral pipeline shall have ear brackets welded on each side of the pipe. The ear brackets are 3" x 3/16". The truce braces are connected to the ear brackets.

Flanges are welded to the end of each section of pipe. The flanges shall be pull tested to 15,000 lbs on the 6-5/8" O.D. pipe and 12,000 lbs on the 5-9/16" O.D. pipe after being welded. The flanges are produced from 3/8" thick steel material. Other types of flanges are unacceptable. The flanges have six holes to bolt together the sections of pipe.

2) Z-Tech Center Pivot Lateral Pipeline

The center pivot lateral pipeline sizes will be 6-5/8" O.D., with an 12 gauge (0.097 in. min. (2.46 mm)) wall thickness (min.). Piping will be formed from A1S1SAE 1010 coil sheet or approved equal. (See Figures 1., 2. and 3. of the Tables and Figures section.)

---

The center pivot lateral pipeline shall have ear brackets welded on each side of the pipe. The ear brackets are a minimum 3" x 3/16". The truce braces are connected to the ear brackets.

Flanges are welded to the end of each section of pipe. The flanges shall be pull tested to 15,000 lbs on the 6-5/8" O.D. pipe and 12,000 lbs on the 5-9/16" O.D. pipe after being welded. The flanges are produced from 5/16" thick steel material. Other types of flanges are unacceptable. The flanges have six holes to bolt together the sections of pipe.

#### E. Center Pivot Lateral Pipeline Outlets

The center pivot lateral pipeline shall use sprinkler outlets which are formed and tapered from the pipe material. The pipeline must be galvanized. The outlets shall be roll-threaded to form a tapered outlet. The thread profile must be tapered such that 3/4" NPT sprinklers and pipes will exactly seal against them. Sprinkler outlets must be exactly placed. The forming of the outlet is accomplished through robotically forming the outlet. Sprinkler outlets with welded couplers and straight threads will be unacceptable.

#### F. Towers

Towers shall be constructed of four legs, each with the dimensions of 4" x 3" x 1/4" and 11' long. Three horizontal ties shall be on one side of the tower structure. They shall be constructed of 1-1/2" x 1-1/2" x 1/8" angle iron. One stabilizer attachment will be on each side of the tower. These stabilizer attachments shall have a cross dimension of 3" x 3" x 3/16". Stabilizer angles shall be crossed and attached to the tower legs at the stabilizer attachments and to the bottom of the truss braces, not to the mainline pipe. The truss brace ends of the stabilizer angles shall be about 5' apart. They will be constructed of 3" x 3" x 3/16" angle iron that is 19' 4-1/2" long.

#### G. Drive Tube Frame

The drive tube shall be 6-5/8", 11 gauge tubing and 13' 8" long. (See Figures 4. and 6. in the Tables and Figures section.)

Tower leg mounting plates shall be welded to the drive tube frame in an "A" type frame. This "A" frame shall consist of a tower leg mount and a leg mount brace. The tower leg mount and leg mount brace shall be formed from steel with a 1/4" thickness. The tower legs are bolted to the "A" type frame.

#### H. Truss Rods and Rod Anchors

Truss rods shall be a fixed length of 22' with large hot headed ends. They will be either 1 1/16" diameter or 3/4" diameter and will not be adjustable. Only one length of truss rods are allowed on the standard span lengths. This is to insure uniform loading and an uniform arch in each span. The truss rods should be anchored to 3/8" rod anchors, not through the pipe flanges. The rod anchors use a safety factor of 2.5. (See Figures 1., 2. and 3. of the Tables and Figures section.)

---

I. Truss Braces, Ties and Plates

Truss braces shall be in a "V-jack" design. There shall be a truss brace pair on each side of the pipeline. The truss braces shall connect to the ear brackets on the pivot lateral pipeline. A truss tie shall connect the bottom of each truss brace pair on each side of the pipe. An angle truss plate is bolted between two truss braces on each side of the pipeline. It is bolted directly underneath the center pivot lateral pipeline to the truss braces. Each set of four truss braces and cross ties shall be spaced 22 feet apart on standard span lengths. The truss braces shall be the dimensions of 2" x 2" x 3/16" and 2" x 2" x 1/8". Truss ties shall be the dimensions of 1-1/2" x 1-1/2" x 1/8" and the third tie shall be the dimensions of 2" x 2" x 1/8". The angle truss plates shall be 1/8" thick. (See Figure 1., 2. and 3. of the Tables and Figures section.)

J. Truss Braces, Ties and Plates

1. Generation II Truss Braces, Ties and Plates

Truss braces shall be in a "V-jack" design. There shall be a truss brace pair on each side of the pipeline. The truss braces shall connect to the ear brackets on the pivot lateral pipeline. A truss tie shall connect the bottom of each truss brace pair on each side of the pipe. An angle truss plate is bolted between two truss braces on each side of the pipeline. It is bolted directly underneath the center pivot lateral pipeline to the truss braces. Each set of four truss braces and cross ties shall be spaced 22 feet apart on standard span lengths. The truss braces shall be the dimensions of 2" x 2" x 1/8". Truss ties shall be the dimensions of 1-1/2" x 1-1/2" x 1/8". The angle truss plates shall be 1/8" thick. (See Figure 1., 2. and 3. of the Tables and Figures section.)

2. ZTech Truss Braces, Ties and Plates

Truss braces shall be in a "V-jack" design. There shall be a truss brace pair on each side of the pipeline. The truss braces shall connect to the ear brackets on the pivot lateral pipeline. A truss tie shall connect the bottom of each truss brace pair on each side of the pipe. An angle truss plate is bolted between two truss braces on each side of the pipeline. It is bolted directly underneath the center pivot lateral pipeline to the truss braces. Each set of four truss braces and cross ties shall be spaced 22 feet apart on standard span lengths. The truss braces shall be the dimensions of 2" x 2" x 1/8". Truss ties shall be the dimensions of 1-1/2" x 1-1/2" x 1/8". The angle truss plates shall be 1/8" thick. (See Figure 1., 2. and 3. of the Tables and Figures section.)

K. Ground Clearance

Minimum ground clearance at the lowest point in the span, which is the truss work, will be 9.0 feet. If low profile towers are required the minimum ground clearance shall be 5.0 feet. (See Table 1. of the Tables and Figures section.)

---

#### L. Pipe and Structure Coatings

Upon fabrication, all structural steel members, such as the span pipe, angle iron, small trussing parts, central pivot members and self propelled tower members, shall be hot-dipped galvanized to ASTM 123-73 specifications. A heavy coat of galvanization of not less than 3.5 mils (0.0035 inches) average shall be applied. Painting and other types of applied coatings will not be acceptable on these members.

#### M. Fasteners

All bolts shall be grade 5 or better. All structural assemblies shall use locknuts on the bolts. The locknuts and bolts shall be zinc plated. (See Figures 1. and 2. of the Tables and Figures section.)

#### N. Structural Safety Factors

A factor of safety of 1.5 applied to yield strength shall be used in all structural calculations except:

- 1.) The system shall be designed to withstand wind loads at velocities of 90 m.p.h. and a 1.1 safety factor. The wind load calculation shall be made without water in the system and with the system located on flat ground.

#### O. AISC Specifications

The pivot structure and all other structural members shall be designed to applicable AISC specifications.

#### P. Welding Requirements

All welding shall be done in accordance with best welding practices as outlined by the American Welding Society (AWS). Welding shall be done by qualified welders.

### **Span Couplers and Joints**

#### A. Aluminum Couplers and Rubber Boots

The coupler construction shall be an external split aluminum coupler comprised of two halves bolted together with a flexible one-piece rubber inner boot having a compression V-lip seal at each end to provide sealing. The gaskets shall seal tight when operating water pressure is applied. The coupler shall be free to flex and shall carry no structural loading. The design shall be such that the inner boot can be changed readily without requiring heavy lifting equipment or extensive dismantling of the span. Exposed rubber boots with tee-clamps will not be acceptable at the tower joints.

#### B. Universal Joint

All joints shall be constructed like a large universal joint for allowing movement of the spans. There shall be four points of attachment on a ring. Attachment will be made with 3/4"-10 x 2" Gr. 5 bolts and 3/4" lock nuts. This joint will distribute motion uniformly. These joints are capable of traveling on lateral or transverse slopes up to 15%. A swivel joint is available to allow the span pipe to rotate independently of adjacent spans. This joint is constructed of a

---

saddle cap weldment and swivel mount coupler assembly. It is capable of traveling transverse slopes up to 30% and lateral slopes up to 15% slope. Ball and socket joints or internal hook and eye type will not be used.

There shall be no internal obstructions causing turbulence or flow reduction within any sections of the pivot pipe.

#### C. Drains

Each joint shall be equipped with an automatic drain in the lowest point of the span. These drains close when under pressure and open when the pressure is relieved. The appropriate drain material shall be selected based upon system operating pressure.

---

## Wheel Gear Boxes for Self Propelled Towers

### A. Wheel Gear Box

The wheel gearbox is located at each wheel and is constructed of a bull gear and worm gear shaft. It shall develop torque adequate to propel the system up to 30% slopes. The wheel gearbox drive shall be capable of delivering at least 120,000 inch-pounds of instantaneous torque and at least 60,000 inch-pounds of CONTINUOUS torque. The gearbox shall deliver vertical loads of 7000 pounds CONTINUOUS and 9000 pounds intermittent load. The wheel gearbox drive shall have an output ratio of 50:1. (See Figure 4. in the Tables and Figures section.)

### B. Wheel Gear Box Specifications

Mechanical specifications of the wheel gearboxes shall include, but will not be limited to, the following considerations:

1. Gear Cases

Gear cases will be designed specifically for center pivot systems.

2. Seals

The wheel gearbox shall have two double lip seals on the worm gear shaft and triple lip seals on the output shaft.

3. Lubrication

Wheel gearboxes shall be filled with 85140-GL5 oil to the normal operating level, which shall submerge all bearings. Wheel gearbox oil quality will meet MIL-2105B specifications. Replacement of oil and oil specifications must be met as noted in the Center Pivot Operation Manuals.

4. Expansion Chamber

The wheel gearboxes will be hermetically sealed. An expansion chamber will be incorporated to maintain minimal changes in internal pressure due to temperature changes (up to 150°F), and providing isolation from water vapor transfer into the gear case. Reduced pressure prolongs seal life and overall gearbox performance by reducing oil leakage.

5. Bull Gear

The bull gear is manufactured from gray iron with a Brinell hardness of 240. The bull gear has an outside diameter of 9" and an inside diameter of 2 1/4". The face width is 2" while the web thickness is 1".

6. Worm Gear Shaft

The worm gear shaft consists of high tensile 1045 material with a Brinell hardness of 210. It has a dual 1" input shaft, a 2-3/8" diameter worm gear and a bearing spread of 6".

---

7. Bull Gear and Worm Gear Shaft Pressure Angle

The bull gear and worm gear shaft pressure angle have been designed at 14-1/2°.

8. Worm Gear Shaft End Caps

The wheel gearbox shall have high strength iron worm gear shaft end caps with steel inserts held by 4 bolts. Each end cap shall have a water ledge to deflect water off the case away from the seal area.

9. Gear Tooth Mesh

The bull gear and worm gear shaft will use a four tooth engagement in its gear tooth mesh.

10. Shafts

Wheel gearbox shaft stress, including the output shaft, shall conform to AGMA Standard #260.01.

The output shaft shall be 2-1/4" in diameter to assure suitable rigidity to maintain gear alignment. This dimension is continues from the wheel shaft bearing and inward to the wheel gearbox.

The output shaft shall be no longer than 1-1/2" between the bearing and the wheel mounting face to minimize weight loads on the shaft.

The wheel mounting face shall have a 6" pilot for wheel support. The pilot is a flange for wheel support. There must be eight 1" diameter lug nuts to bolt the wheel to the wheel mounting face. The face shall be 9" in diameter. The non-pilot thickness shall be 1/2". With the pilot, the thickness of the face will be 28/32". Wheel mounting faces without the pilot face or with lug nuts smaller than 1" in diameter will be unacceptable.

11. Mounting

The wheel gearbox will use five 1/2" bolts to attach the gearbox to the gearbox mounting plate welded to the drive tube. The bolt holes are in a circle pattern.

12. Gearing

Each wheel gearbox reduction mesh will be capable of passing the following 500 hour unidirectional qualification test without scoring, pitting or breaking.

- a. Random loading.
- b. Minimum output torque - 10,000 in-lb
- c. The output torque shall vary between 18,000 and 55,000 in-lb and will be applied for no less than 10% of the time.
- d. The load shall be at least 24,000 in-lb for at least 25% of the time.
- e. Power will be interrupted each minute (approximately) and the mesh allowed to remain static for one minute (approximately) to provide a "start-stop" cycle.

---

C. AGMA Standard #440.03

The design and rating of all wheel gearbox meshes will be of substantial agreement with the norm established in AGMA Standard #440.03. The bull gear and worm gear shaft shall achieve proper fit at the beginning of operations.

## **Drive Shafts and Aluminum Couplers**

A. Drive Shafts

Drive shafts shall be 7/8" square. They shall be able to deliver a maximum torque to the wheel gearboxes. Minimum deflection of the drive shaft shall not exceed 1/360 of the span length.

B. Aluminum Couplers

Aluminum drive shaft couplers will be used at the end of each drive shaft. Aluminum couplings used to join the center drives, drive shafts and wheel gear boxes and will be designed to facilitate removal. (See Figure 4. in the Tables and Figures section.)

## **Center Drive Gear Boxes and Electrical Motors**

A. Center Drive

Each tower shall be propelled by a center drive gearbox and an electrical motor approximately located at the center of each drive tube. (See Figure 4. in the Tables and Figures section.)

B. Center Drive Specifications

Mechanical specifications of the center drive gearboxes shall include, but will not be limited to, the following considerations:

1. Gear Cases

Gear cases will be designed specifically for center pivot systems.

2. Seals

Center drive output rotating shaft sealing shall include four single lip, 2 seals per side, spring loaded oil seals.

3. Lubrication

Center drive gearboxes shall be filled with 20W-GL4 oil to the normal operating level, which shall submerge all bearings. Replacement of oil and oil specifications must be met as noted in the Center Pivot Operation Manuals.

---

#### 4. Gears

The center drive gearbox shall be a triple gear reduction and of the spur gear type. The gears shall provide an output ratio of 40 to 1 for the electrical motor. No helical gears are used.

The gears shall be made from powdered metal and not heat treated or machined.

#### 5. Output Test

The center drive gearbox shall be capable of 7200 in-lbs output torque. It shall be 95% efficient.

### C. NEMA and IEEE Standards

The electric motor's design shall comply with applicable provisions of NEMA and IEEE standards.

### D. Electric Motor

The electric motor will be designed specifically for center pivot applications including the special considerations of keeping moisture out. The electric motors shall be provided with a metal shroud which protects it from rainfall and spray applications. In addition, the shroud shall provide for movement of cooling air over the surface of the electric motor. The shroud may be covered by a plastic motor cover for additional water protection.

The electric motors shall be rated for a continuous duty cycle and have inherent overload protection.

The winding insulation shall be double varnish dipped and baked, and shall be NEMA Class "B" or better.

Ball bearings shall be double sealed.

### E. Electric Motor Options

Centerdrive motors for the center pivots shall consist of one or a combination of both of the following:

1. OPTION A: 3/4 HP, 43 RPM
  - 1.5 amp (full load) at 480V and 1.43 amps (full load) at 380V
  - a 3/4 HP TENV
  - 40:1 ratio
  - 43 RPM output at 60 HZ and a 33 RPM output at 50 HZ
  - 3 phase
  - a 1000 in.-lb. torque (full load).

---

2. OPTION B: 1-1/2 HP, 59 RPM

- 2.2 amp (full load) at 480V and 2.6 amps (full load) at 380V
- a 1.5 HP TENV
- 40:1 ratio
- 86 RPM output at 60 HZ and 71 RPM output at 50 HZ
- 3 phase
- 1000 in-lbs torque (full load).

## Wheel Sets

### A. Wheel Specifications

Each self-propelled tower shall be provided with two rubber tires. All tires provided shall be of the same manufacturer and model. These will be of an agricultural load tractor type with a suitable lug design (R-1) and an adequate load rating. (See Figure 4. in the Tables and Figures section.)

### B. Wheel Options

Wheel sets selected shall consist of one or more of the following options in Table 2.

Table 2.

Tire Size	Tread Width	Width of Rim	Diameter	Circumference	Contact Area *
11 x 22.5	11.3"	8.25"	40.0"	126.0"	204 in <sup>2</sup>
11 x 24.5	10.4"	8.25"	43.0"	135.0"	242 in <sup>2</sup>
11.2 x 24	10.4"	8"	43.0"	135.0"	242 in <sup>2</sup>
11.2 x 38	11.2"	10"	57.0"	179.0"	320 in <sup>2</sup>
14.9 x 24	12.9"	8"	49.8"	156.5"	320 in <sup>2</sup>
14.9 x 24	14.5"	12"	49.8"	179.0"	346 in <sup>2</sup>
16.9 x 24	16.9"	15"	53.0"	166.5"	533 in <sup>2</sup>

Note: \* Contact area is based on 3" soil penetration.

---

## General Electrical Specifications

### A. ASAE Standards

Electrical service to center pivot equipment should meet the American Society of Agricultural Engineers (ASAE) Standard S397.2 "Electrical Services and Equipment for Irrigation." This standard is approved by the Irrigation Association.

The center pivot shall meet the American Society of Agricultural Engineers (ASAE) Standard S362.2 "Wiring and Equipment for Electrically Driven or Controlled Irrigation Machines."

### B. NEC Standards

The following sections of the National Electric Code (NEC) apply to electric drive center pivot irrigation systems, and shall be adhered to accordingly.

- 1.) Article 250-51 Effective grounding.  
Article 250-114 Effective grounding.
- 2.) Article 310 Minimum size of conductors.
- 3.) Article 210-5 Color code for branch circuits.
- 4.) Article 430 Motors, motor circuits or controlled.
- 5.) Article 675 Irrigation machines.

### C. Control Panel Housing

All control panels shall be readily accessible to the maintenance personnel. They shall be totally weatherproofed. Entrances into, exits from and penetrations of the enclosure shall be made in such a manner as to reduce the possibility of collection of water or contaminants at the point of connection and shall also be made in such a manner as to preserve the minimum NEMA 3R rating of the enclosures. NEMA 3R states that the control panel enclosure is outdoor and weather resistant. Dimensions of enclosures shall not be less than the maximum dimensions of the enclosed equipment plus the required electrical clearances as specified in the National Fire Protection Standard No. 70, National Electrical Code. Enclosures shall be made of corrosion resistant materials and shall have doors covering the controls to prevent damage. Doors will have non-corroding hinges or other means of attachment. Locking mechanisms shall also be provided on the master control panel and the main disconnect.

---

#### D. Master Control Panel

The Master Control Panel for each pivot shall be mounted to the pivot point. The Master Control Panel shall be one of the options shown below.

1. OPTION A: FieldBOSS Panel - Programmable

The advanced panel shall include the following controls and features.

- a. The FieldBOSS control panel for each pivot shall be mounted to the pivot point.
- b. The FieldBOSS control panel shall include the following controls and features.
  - System power controls
  - Forward and reverse directional controls
  - Digital percent timer to enter inches or percent rates
  - Absolute position monitor and controls of field location (0-359°)
  - Auto-restart
  - Programmable auto-shutdown and auto-reverse controls
  - Two (2) auxiliary controls
  - Nine (9) automated user-defined irrigation programs with up to twenty (20) steps each
  - Four (4) programmable endgun tables with up to eight (8) steps each
  - 50 step history log showing date, time, location and pivot events
  - Timers for run-time, endgun, pivot, pump, auxiliary 1 and auxiliary 2
  - Programmable service stop
  - Monitor pressure with optional sensors
  - Pump protecting delays and timer limits
  - Deviation of speed based on temperature or time
  - Low pressure shutdown and restart
  - Low voltage shutdown and restart
  - Pump load management
  - User-friendly menus and prompts
  - Easy on-line diagnostics on the run-time screen
  - Rainfall shutdown (with optional sensor)
  - High wind shutdown (with optional sensor)
  - High flow and low flow warnings (with optional sensor)
  - FieldNet and Telemetry compatible
- c. A nameplate shall state the manufacturer's name, the design voltage, phase, frequency of the incoming power supply and the amperage per phase, which shall be the ampacity of the recommended over current protection for the main power circuit.
- d. Transformers shall be capable of handling voltage reductions required for all functions of the control system. Transformers shall be of the isolation type with proper over current protection for the transformers, conductors or control device they serve. All control circuits shall operate at 120 vac. except for the remote pump kill, which operates at 24 vac.

- 
- e. The panel classification shall be NEMA 3R - rain proof - sleet resistant - outdoor type.
  - f. There must be a main disconnect in the panel to shut off the flow of power through it.
  - g. A four (4) line by 40 character LCD screen shall present information on the following:
    - Day of week
    - Date (month and day)
    - Time (hour:minute:second am/pm)
    - Manual mode or program mode (program number and next step to run)
    - Pivot Pressure
    - Temperature
    - Voltage
    - Absolute Field position (0-359°)
    - Full Circle Time (at current application rate)
    - Service stop setting
    - Auto Reverse Status (on/off)
    - Auto Restart Status (on/off)
    - Pivot status
    - Rotation Status
    - Depth Applied or Percent Setting
  - h. The LCD screen should also provide the following statuses:
    - Countdown of pump timers (restart delay, pressure-up delay and pump recovery)
    - Hours of operation for: pivot, pump, endgun, auxiliary 1 and auxiliary 2
    - With optional flow meter: water flow rate, two (2) totalizers (one non-re-settable and one re-settable)
    - With optional rain sensor: total rainfall, period rainfall, shutdown value and shutdown period, where total and period rainfall is re-settable and logs the date reset
    - With optional wind sensor: wind heading, wind speed, recorded high, wind speed shutdown and delay time
  - i. System operating information must also be shown via LED's next to the applicable function keys for the following information:
    - Rotation status: reverse, off or forward
    - Status of auxiliary equipment
    - Wet or dry mode
    - Endgun status
  - j. It must have the ability to operate the system either manually or via a preset program.
  - k. There will be a Wet-Dry operations key to permit operation of the pivot during periods when no spraying is required.

- 
- l. Speed of the last tower shall be controlled by either percent setting or depth of application.
  - m. There shall be a recording device to accumulate the total number of hours of operating time of the pivot, pump, end gun and (2) auxiliaries.
  - n. An Automatic Restart feature is available to restart the pivot after a momentary power interruption and after power is restored.
  - o. There will be a Low Temperature shutdown feature to prevent the pivot from operating below a preset temperature.
  - p. There is the capability to easily add one or more of the following optional features:
    - There can be an Automatic Shutdown/Automatic Reversing mechanism controlled at an individual tower. This feature also allows the pivot to travel over a given arc, but either shuts down or reverses when the mechanism touches a barricade placed at one of the towers. This feature **MUST** be used when the system arc is determined by obstacles in the tower's path.
    - An End Tower light can be added, which readily allows the operator to see from a distance when the center drive motor for the last tower is on or off.
    - A Pivot Light is an option that remains on the entire time that the system is operating.
    - A Main Panel Light is available to illuminate the Master Control Panel and facilitate operation of the system at night.
  - q. The panel must have the ability to be programmed based upon its position in the field. The degrees of rotation of the system are to be determined by an absolute position encoder mounted near the top of the pivot riser.
  - r. The panel is adaptable for use with FieldNet Full Control.
  - s. The panel is adaptable for use with a Telemetry package.
2. OPTION B: GrowSmart FieldVISION Panel - Programmable
- The advanced panel shall include the following controls and features.
- a. The FieldVISION control panel for each pivot shall be mounted to the pivot point.
  - b. The FieldVISION control panel shall include the following controls and features.
    - System power controls
    - Forward and reverse directional controls
    - Digital percent timer to enter inches or percent rates
    - Absolute position monitor and controls of field location (0- 359°)
    - Auto-restart
    - Programmable auto-shutdown and auto-reverse controls

- 
- One (1) accessory controls, typically used for chemigation or fertigation
  - Three (3) AREA Plans (A-C) with up to ten (10) definable areas
  - Two (2) endgun controls, with up to eight (8) steps each
  - 50 step history log showing duration, location and pivot events
  - One (1) programmable direction plan
  - Timers for run-time, endguns, pivot, pump, and chemigation/fertigation
  - Programmable service stop
  - Monitor pressure with optional sensors
  - Pump protecting delays and timer limits
  - Low pressure shutdown and restart
  - Low voltage shutdown and restart
  - User-friendly icons, menus and prompts
  - Easy on-line diagnostics on the run-time screen
  - High flow and low flow warnings (with optional sensor)
  - FieldNET compatible
- c. A nameplate shall state the manufacturer's name, the design voltage, phase, frequency of the incoming power supply and the amperage per phase, which shall be the ampacity of the recommended over current protection for the main power circuit.
- d. Transformers shall be capable of handling voltage reductions required for all functions of the control system. Transformers shall be of the isolation type with proper over current protection for the transformers, conductors or control device they serve. All control circuits shall operate at 120 vac. except for the remote pump kill, which operates at 24 vac.
- e. The panel classification shall be NEMA 3R - rain proof - sleet resistant - outdoor type.
- f. There must be a main disconnect in the panel to shut off the flow of power through it.
- g. A graphic display screen, 2-1/2" x 4-1/2" viewable display area shall present information on the following:
- Operation mode (manual, EZ Plan or Advanced Plan) with plan in operation and area or step being executed
  - Pivot Pressure
  - Temperature (option)
  - Voltage
  - Absolute Field position (0-359°)
  - Full Circle Time (at current application rate)
  - Service stop setting
  - Auto Reverse Status (on/off)
  - Auto Restart Status (on/off)
  - Pivot status (graphically)
  - Rotation Status
  - Depth Applied and/or Percent Setting

- 
- Language choices
  - Unit of measure selection
  - Navigation icons
- h. The screen should also provide the following statuses:
- Countdown of pump timers (restart delay, pressure-up delay and pump recovery)
  - Hours of operation for; pivot, pump, endgun, and chemigation
  - With optional flow meter; water flow rate (non-re-setable)
- i. System operating information must also be shown via Icons on the screen for the following information:
- Rotation status (reverse, off or forward)
  - Status of chemigation
  - H2O operation, on (wet) or off (dry)
  - Endgun status
  - Auto-Reverse on or off
  - Auto-Restart on or off
  - Operation mode
- j. It must have the ability to operate the system either manually or via a preset plan.
- k. There will be a H2O ON/OFF operation key to permit operation of the pivot during periods when no spraying is required.
- l. Speed of the last tower shall be controlled by either percent setting or depth of application.
- m. There shall be a recording device to accumulate the total number of hours of operating time of the pivot, pump, (2) endguns, (2) accessories and a chemigation/fertigation control.
- n. An Automatic Restart feature shall be available to restart the pivot after a momentary power interruption and after power is restored.
- o. There will be a Low Temperature shutdown (with optional sensor) feature to prevent the pivot from operating below a preset temperature.
- p. There will need to be the following features:
- An End Tower light must be available, which readily allows the operator to see from a distance when the center drive motor for the last tower is on or off.
  - A Main Panel Light must be available to illuminate the Master Control Panel and facilitate operation of the system at night.

---

q. The panel must have the ability to be programmed based upon its position in the field. The degrees of rotation of the system are to be determined by an absolute position encoder mounted near the top of the pivot riser.

r. The panel will be used with a FieldNET telemetry system

3. OPTION C: FieldBASIC Panel - Not programmable

The FieldBASIC panel shall include the following controls and features.

a. The FieldBASIC control panel for each pivot shall be mounted to the pivot point.

b. A nameplate shall state the manufacturer's name, the design voltage, phase, frequency of the incoming power supply and the amperage per phase, which shall be the ampacity of the recommended over current protection for the main power circuit.

c. Transformers shall be capable of handling voltage reductions required for all functions of the control system. Transformers shall be of the isolation type with proper over current protection for the transformers, conductors or control device they serve. All control circuits shall operate at 120 VAC. except for the remote pump kill, which operates at 24 VAC.

d. The panel classification shall be NEMA 3R - rain proof - sleet resistant - outdoor type.

e. There must be a main disconnect in the panel to shut off the flow of power through it.

f. There shall be system analyzer lights to monitor all of the following:

- Control power
- Safety circuit status
- Pressure switch
- Last tower movement
- Reverse control circuit
- Forward control circuit
- Control circuit power
- Pump control

g. There must be a Wet-Dry operations switch to permit operation of the pivot during periods when no spraying is required.

h. There shall be a percentage timer which controls the speed of the end tower.

i. There must be a manual reversing control mechanism.

j. There shall be a 0-600 volt AC meter to monitor incoming power.

- 
- k. There shall be a recording device to accumulate the total number of hours of operating time.
  - l. An On-Off switch is included to turn off or on the pivot.
  - m. There must be a Start-Run switch.
  - n. The panel must be capable of easily adding one or more of the following optional features:
    - There can be an Automatic Shutdown/Automatic Reversing mechanism controlled at the pivot point. This feature shall permit travel of the pivot through a specified arc of rotation, and either shut the system down at the end of the arc or change direction and continue to operate.
    - There can be an Automatic Shutdown/Automatic Reversing mechanism controlled at an individual tower. This feature also allows the pivot to travel over a given arc, but either shuts down or reverses when the mechanism touches a barricade placed at one of the towers. This feature **MUST** be used when the system arc is determined by obstacles in the tower's path.
    - There is an optional Automatic Restart feature that restarts the pivot after a momentary power interruption and after power is restored. This feature only operates if the main disconnect switch is not disconnected.
    - A Low Temperature shutdown feature is an option to prevent the pivot from operating below a preset temperature.
    - An End Tower light is available. It allows the operator to see from a distance when the centerdrive motor for the last tower is on or off.
    - A Pivot Light is an option that remains on the entire time that the system is operating.
    - A Main Panel Light is available to illuminate the Master Control Panel and facilitate operation of the system at night.
  - o. The panel is upgradable for use with a FieldNet Telemetry Unit.

#### E. Main Disconnect Switch

A main disconnect switch is to be provided with over current protection and capable of being locked in the OFF position. It is located at the point of connection of electric power to the machine. The switch shall be rated at 30 amps and 600 volts minimum. A suitable lightning arrestor shall be provided.

#### F. Tower Alignment Control

Tower alignment control shall use microswitches and motor contactors actuated through a mechanical linkage from a unknuckle joint. The tower alignment mechanism shall be electrical and mechanical operated. The mechanical linkage shall be a threaded stainless steel alignment rod. One end of the threaded rod shall have a metal ball and socket joint bolted to a cam arm. The cam arm is bolted to a cam that it turns, which then actuates two microswitches. One microswitch shall control the "on" and "off" intervals of the center drive motors. A second switch shall act as a safety shut down of the center pivot to the pivot control panel if misalignment occurs. The other end of the alignment rod shall also have a

---

metal ball and socket joint that is bolted to an arm welded to the unknuckle joint. This end of the alignment rod must adjustable.

There shall be a spring connected to the cam to provide resistance to the cam arm. It shall be 0.047" hard drawn wire with a 0.375" O.D. Its length at rest shall be 2-3/4". It shall be zinc plated.

The cam and cam arm are constructed of special acetal-delrin 500 materials. There shall be no steel cam assemblies or nylon bushings.

The alignment mechanism will not be affected by changes in the terrain for slopes up to 30%. The alignment system shall be capable of operating when the machine is reversed without the necessity of making adjustments.

If the system is over 1600' in length, an optional system of wire alignment or long system non-wire alignment may be required.

#### G. Machine Safety

Machine safety shall shut the system off if normal alignment is not maintained.

There shall be safety interlocks. One such device is an electrically

actuated misalignment mechanism to render the system inoperative if misalignment of the system occurs. The water supply is also shut off during the time the system is rendered inoperative. An overwatering safety device will render the pivot inoperative if the end tower stops for more than a pre-set number of minutes. A controlling timer shall be of the variable type with time settings between zero and five minutes, and will adjust per main panel percentage rate.

#### H. Tower Control Box

Each tower shall have a tower box to control its functions. The tower box is UL/C.S.A. listed - Industrial Control Panel. The box shall include:

1. A definite purpose extended life contactor rated at 25 amps, 600 volts, 10 h.p., and for 1 million mechanical operations.
2. Microswitches rated 277 volts at 15 amps, 1/4 h.p. and tested to 10 million cycles. They shall be constructed of a snap spring, type 301 stainless steel, with a copper inlay strip and with silver contacts.
3. On-off switch rated at 10 amps and 600 volts.

Each tower box shall be fitted with a suitable weather-tight enclosure. This enclosure shall be constructed of a polycarbonate base and polypropylene cover. The cover must have a positive seal against the base and it must be corrosion resistant. No steel enclosures or bases will be used. Neither shall any foam seals be used to seal the cover to the base.

#### I. Grounding

All systems shall have proper grounding. The grounding conductor must be supplied with the electrical service to serve as an interconnection between the power source ground and

---

all non-current carrying metal parts of the installation. This would include the disconnect switches, pump panels, conduit, junction boxes, pump motors and the center pivot. This conductor must be sized properly to carry any fault current that could develop. The center pivot and master control panel shall be connected to a driven grounding electrode in accordance with the latest edition of the National Electrical Code (section 250).

#### J. Safety Signs

Safety signs describing the automatic starting of the machine, grounding requirements, high voltage, caution and other pertinent safety signs shall be provided and prominently displayed.

#### K. External Collector Ring

An external collector ring shall be used on all 5-9/16", 6-5/8" and 8" pivot point structures. The external collector ring shall have a minimum of 10 rings rated at 30 amps and 600 volts. Dual spring loaded brushes on the rings shall have an area of 0.25 sq. in. External collector ring enclosures shall be weather tight to eliminate the possibility of ingress of moisture or contaminants at the points of connection. The shield is constructed of fiberglass. The electric cable connecting the main panel to the collector ring shall be outside any water carrying member. A power cable going through the inside of riser is unacceptable.

#### L. Position Encoder (FieldBOSS and FieldVision Panel)

The position encoder shall be located in a water tight enclosure. The enclosure shall be constructed of the same material that the tower box is constructed. This enclosure shall be bolted to the pivot head. An 8" pin ring shall be bolted to the pivot ell pipe. The position encoder shall have a shaft attached to it. The shaft shall be attached to an 8" encoder gear. The encoder gear shall have grooves along the edges that the pins of the 8" pin ring rest.

The position encoder shall be an absolute position monitor and know where exactly the rotation of the pivot is at from 0 to 359 degrees. As the pivot ell rotates the 8" pin ring, it shall turn the 8" gear plate. This plate will thus turn the absolute position encoder.

#### M. Conductors

Conductors in the irrigation cable shall be at least #14 gauge copper type THWN stranded for all control circuits, at least #18 gauge copper type THWN stranded for low current signal carrying circuits and at least #14 gauge copper type THWN stranded for all three phase motor power conductors. Conductors used to connect or interconnect to or between components within an enclosure shall be rated not less than 600 vac. for circuitry utilizing 300 volts or less and not over 600 vac. Cable jacketing shall be resistant to sunlight, moisture and corrosion as per NEC 675-4. It should also provide mechanical protection, flexibility and be suitable for operation within a temperature range of -40°F to 140°F. All conductors shall be color coded for proper identification and this coding shall be uniform throughout the entire system.

#### N. Booster Pump

In some instances, it may be necessary to run the end gun with a booster pump. Two options are available and are listed below.

---

1. OPTION A: 130 GPM Booster Pump

The 130 GPM pump shall operate at 4 amps (full load) at 460V. Additionally, it shall operate at a maximum of 130 GPM and a minimum of 65 GPM. At 60 HZ the booster pump motor shall run at 3450 RPM.

2. OPTION B: 200 GPM Booster Pump

The 200 GPM pump shall operate at 6.2 amp (full load) at 460V. Additionally, it shall operate at a maximum of 200 GPM and a minimum of 100 GPM. At 60 HZ the booster pump motor shall run at 3450 RPM.

Any booster pump used shall be controlled by a panel with an on-off switch rated for 600V at 10 amps and a reversing contactor rated for 600V and 30 amps.

O. Boost Transformer Package

On long systems where voltage drop becomes excessive, the use of a boost transformer package may be required. The boost transformers will boost the voltage by approximately 5% of the incoming voltage into the transformer. The placement of the boost transformers shall be placed according to the manufacture's specifications.

---

## Nozzling Design

General: Applications of Irrigation Water shall be designed in accordance with the guide developed by the Irrigation Association (I.A.) in relation to:

- A. Water application must not:
  - 1. Create crop damage
  - 2. Create soil damage
  - 3. Cause runoff
- B. Coefficient of uniformity must be at least 80% as measured using I.A. test procedures and ASAE Standard S436.1.
- C. The sprinkler type and mounting configuration shall be determined by considering the following factors:
  - 1. Desired Evaporation Amount
  - 2. Acceptable Wind Drift
  - 3. Size of Suspended Particles
  - 4. Intake Rates of the Soil
  - 5. Percent Solids
  - 6. PSI of the System
  - 7. GPM of the System
  - 8. Material Buildup on Pivot Components
  - 9. Odor Control
  - 10. Hydraulic Loading on the Soil

---

D. The operator of the irrigation system shall be responsible for managing the application of the wastewater. The operator should be familiar and follow federal, state and local guidelines pertaining to the following points.

These include:

1. Eliminating excessive applications.
2. Timely applications to reduce leaching, reduce soil erosion, reduce water and nutrient runoff and increase use efficiency.
3. Rotate crops to reduce chemical inputs and pesticide use.
4. Should consider the nitrogen, phosphorus and potassium levels of the wastewater and how to best apply those nutrients to the crops' advantage.
5. Should consider the odor of the wastewater.
6. Should watch and control placement of wastewater if there are trace elements and heavy metals in the wastewater.
7. Should watch and control placement of wastewater if there are pathogens in the waterwater.
6. Should consider the drift or runoff from the site of application into neighboring property;
7. Should consider the hydraulic loading on the soil.
8. Should keep solid particle size smaller than the smallest nozzle.



# Engineering Design Reference and Resource Guide

## Options Specifications

Zimmatic Land Application Systems



---

*Notes*

# *Table of Contents*

## **OPTIONS SPECIFICATIONS**

Option.....	4-5
Remote Monitor and Control .....	4-6
Telemetry .....	4-8
Stainless Steel Pivot Pipeline.....	4-10
Large Volume Guns .....	4-11

---

*Notes*

---

## OPTIONS SPECIFICATIONS

There are some of the following options that will fit the clients in agricultural operations, food processing operations, industrial operations and municipalities.

- A. Some clients may want to be able to operate the pivots by remote control. This can be done by a Remote Control and Monitoring system called FieldNet. It allows the operator to control a pivot from a landline or cellular phone or a business band radio. This can be used with a FieldBOSS pivot control panel, a FieldVISION MAXfield pivot control panel or a non-Zimmatic pivot control panel.
- B. The FieldNet Telemetry Network may be ideal if your client has a large number of center pivots and/or needs to keep records of the amount of wastewater applied by a particular center pivot. This tool is a Windows-based software used to transform the personal computer into a state-of-the-art tool for irrigation management. It is used in conjunction with a FieldBOSS control panel and FieldVISION control panel.
- C. If your client has very corrosive wastewater they may require one of the three following options to transport the water along the center pivot pipe: A Stainless Steel Pipe Line or Polylined pipeline. This is because very corrosive water can cause various levels of corrosion in the center pivot pipeline.
- D. When your clients wastewater contains more than 4% solids Large Volume Guns may be required. Lindsay Corporation provides the Large Volume Guns to mount on the center pivot pipeline.

---

## REMOTE MONITOR AND CONTROL

- A. Lindsay Corporation has available a product that allows for remote operation of the system in conjunction with a business band radio, landline phone or cellular phone. It may be used on an FieldVISION pivot control panel, an FieldBOSS pivot control panel or a non-Zimmatic pivot control panel. The unit provides operational information in non-synthesized operation from a remote location. The water pressure, pump shutdowns and power may be monitored with voice command. The voice command includes complete system reports in the "Status Message". The FieldNet reports the following conditions to the grower:
- Forward, Reverse or Off
  - Wet or Dry operation
  - System Speed in Percent
  - Status of Auxiliaries (FieldBOSS)
  - Pressure (FieldBOSS)
  - Time of operation (option on FieldBOSS)
  - Location in degrees (standard on FieldBOSS)
  - Current GPM (with optional flow meter), (Voice command only)
  - Current wind speed and wind heading (with optional wind sensor), (FieldNet only)
  - Current rainfall accumulation (with optional rainfall sensor), (Voice command only)
- B. The Voice command allows the grower to remotely control his system. The grower can control the following pivot functions:
- Start or Stop System
  - Change Speed
  - Select Wet or Dry Operation
  - Forward and Reverse Control
  - Start or Stop Pump
  - Turn Auxiliaries On or Off
  - Run a Program (FieldBOSS)
- C. Voice command is also programmed with a pivot alarm to automatically advise you when a trouble condition is present; such as the following:
- When a pump shuts down prematurely
  - Low pressure warning (FieldNet)
  - Loss of power
  - High voltage (FieldNet)
  - Low temperature
  - Low flow and high flow (FieldNet)
  - A safety error, etc.
- D. Voice command requires a battery back up in case of loss of power.

## Control Panels

Key Features	FieldBASIC	NEW FieldVISION w/o position	NEW FieldVISION w/ position	FieldBOSS w/position
<b>Controls</b>				
Select percent rate	✓	✓	✓	✓
Select depth (inches/mm)		✓	✓	✓
Stop or start forward/start reverse	✓	✓	✓	✓
Water on/off	✓	✓	✓	✓
Accessories on/off		1	1	3
Programmable service stop			✓	✓
Programmable end guns			2	2
Simple direction plan		✓	✓	
Programmable field area plans			✓	✓
Step-by-step programmability by date/time, day of the week, etc.				✓
Power auto-restart		✓	✓	✓
Pressure auto-restart		✓	✓	✓
Programmable soft barrier			✓	✓
Water hold time at a barrier		✓	✓	✓
Pressure, flow, voltage and temperature shutdown limits		✓	✓	✓
Pump and pressurization limits/delays		✓	✓	✓
Load control feature to prevent operation during peak rates				✓
<b>Monitoring</b>				
Field position			✓	✓
Direction or stopped	✓	✓	✓	✓
Pressure reading		✓	✓	✓
Voltage reading	✓	✓	✓	✓
Temperature reading		✓	✓	✓
Flow sensor reading and logger		✓	✓	✓
Calculated hours per revolution		✓	✓	✓
Specific fault status display		✓	✓	✓
History log of pivot events		✓	✓	✓
Number of function timers	1	6	6	8
Rainfall and wind sensors for programmable shutdowns				✓
<b>Design</b>				
Backlit display		✓	✓	✓
Lightning arrestor	✓	✓	✓	✓
Transient and induced voltage protection		✓	✓	✓

---

## TELEMETRY PACKAGE

### Hardware Specifications

A. Telemetry features and capabilities include the following:

1. It shall have Radio Telemetry that connects to a COMM port on the personal computer (PC) and provides remote access to the master control panel. This access allows the user to do everything from the PC that could be done at the key pad of the FieldVISION control panel.
2. It shall have the ability to automatically compile information to aid record keeping and reporting.
3. It shall have a summary screen that displays information on each pivot including hours of operation, water use, pumping cost and environmental data.
4. Each Advance control panel shall have special telemetry software (EPROM) that enables the pivot events to be relayed to the Base Station in real time without the need to poll for status.
5. The Base Station software shall include drawing tools to draw circles or part circles, polylines, polygons, rectangles, squares, circle ellipses and text.
6. The Base Station software shall include drawing properties to allow the drawing of non-pivot shapes such as the solid choice of colors and/or patterns.
7. The Base Station software shall include two views for displaying the pivots. One view is a map view showing the colored circles. The second view is a table view that represents information in a spreadsheet.
8. The Base Station software shall display the pivots on the map with different colors representing unique statuses. The colors shall be coded like the following:
  - Blue = Running wet
  - Orange = Running wet with one or more auxiliaries on
  - Green = Running dry
  - Gray = Pivot is off
  - Yellow = Running in a warning or timer countdown
  - Red = Shutdown
9. The Base Station software shall display the location and direction of travel of the pivots on the map with a solid black line and arrow, which is part of the pivot circle. A service stop location shall be displayed with a dashed line.
10. The Base Station software shall have the capability to monitor more than one map site at a time
11. The Base Station software shall be compatible with Microsoft's Access database program for Windows 95 or higher.
12. The Base Station software shall interface with the call-out alarm so whenever a circle turns red or yellow, the call-out alarm will call up to two (2) phone numbers to announce the shutdown or warning.
13. The Base Station software shall have the capability to select which alarm conditions will or will not be called out.
14. The call-out alarm shall connect to a COM port on the PC and a phone line.

---

B. Requirements at the Pivot include the following:

1. There shall be a Telemetry panel located at the pivot point and connected to the FieldVISION control panel.
2. Communication (Radio, Phone or Direction Connection)
  - a. The telemetry panel shall be equipped with a 12 VDC power supply, packet modem using AX2512V2 protocol, data radio programmed between 450-470 MHz UHF and an UHF antenna.
  - b. The panel shall be equipped with a Hayes compatible phone modem to use with either, landline or cellular phone and a cellular connection (Motorola S1936D).
  - c. The panel must be equipped with a RS-232 to RS-485 converter for direct connection to the personal computer (PC).

Note: There is a limited number of pivots and a limited distance applicable with this method.

C. Requirements at the Base Station include the following:

1. The Telemetry software shall run under Windows 95 or higher and on an IBM compatible personal computer (PC) with the following minimum hardware specifications (customer supplied):
  - Pentium 90 MHz processor or higher
  - 16 MB RAM or higher
  - 20 MB of free hard drive disk space
  - CD ROM for loading software
  - Two (2) free COM ports required, three (3) recommended
  - Recommend a bus mouse over a serial mouse
  - SVGA monitor recommended
  - Carbon Copy or PC Anywhere software recommended to remote control and support
2. Communication (Radio, Phone or Direct Connection)
  - a. The Base Station shall be equipped with Windows-based Telemetry software, 12VDC power supply, packet modem using AX2512V2 protocol, data radio programmed between 450-470 MHz UHF and an UHF antenna
  - b. The Base Station shall be equipped with a Hayes compatible phone modem to use with either, landline or cellular phone and a cellular connection (Motorola S1936D).
  - c. The Base Station must be equipped with a RS-232 to RS-485 converter for direct connection to the personal computer (PC).

Note: There is a limited number of pivots and a limited distance applicable with this method.

- 
3. The base station shall be equipped with a phone call-out alarm and a dedicated phone line. This alarm shall call up to, two (2) phone numbers for each pivot. This alarm shall provide a voice identification of announcing the word "telemetry" so the person that answers the phone knows what is calling. Once the person acknowledges by pressing the star key (\*) on the phone, the alarm will then announce the pivot name and specific reason for shutdown. These reasons can include the following:
- Safety shutdown
  - Low temperature shutdown
  - Low pressure shutdown
  - Low pressure warning
  - Load management shutdown
  - Low voltage shutdown
  - High voltage shutdown
  - Service stop shutdown
  - Power company shutdown
  - Low flow warning
  - High flow warning
  - Wind speed shutdown
  - Rainfall shutdown

### **STAINLESS STEEL PIVOT PIPELINE**

An option Lindsay Corporation can provide for very corrosive water is a center pivot with stainless steel lateral pivot pipe and any combination of the below features. The consultant engineer can include any combination of the following parts in the design specifications bid.

- A. Stainless steel lateral pivot pipeline.
- B. Stainless steel hardware i.e. fasteners, lock nuts and bolts.
- C. Stainless steel alignment rods and adjustment nuts.
- D. A stainless steel pivot control panel enclosure.
- E. A stainless steel shell on the stater of the center drives.

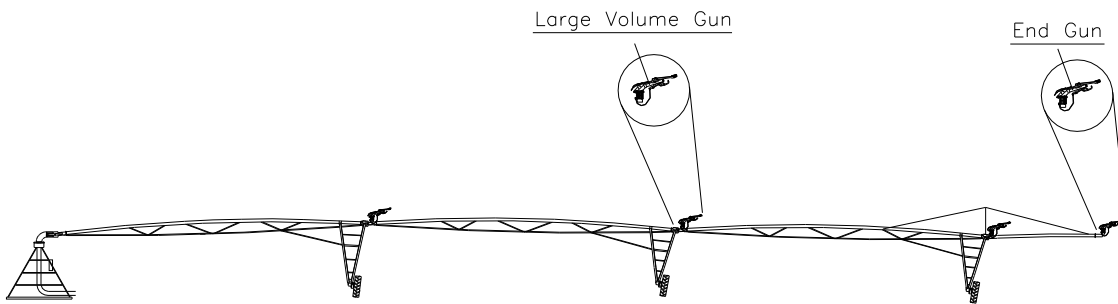
---

## LARGE VOLUME GUNS

- A. When solids are greater than 7%, large volume guns are recommended.
- B. The large volume guns will be placed at the tower joint. A pivot end joint with a 2" coupling is required at this location. (See figure 9.)
- C. The design of a large volume guns spacing and nozzle sizes should follow the same considerations as section VIII, Nozzling, in the General Specifications.

**Figure 9.**

Large Volume Gun



---

*Notes*



# Engineering Design Reference and Resource Guide

## Tables and Figures

**Zimmatic Land Application Systems**



---

*Notes*

# *Table of Contents*

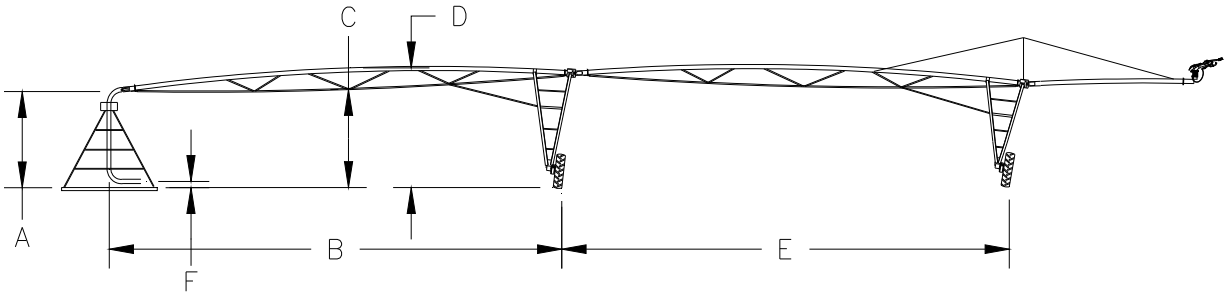
## **TABLES and FIGURES**

<b>System Dimensions .....</b>	<b>5-5</b>
<b>Overhang Lengths.....</b>	<b>5-6</b>
<b>Domestic Span Configuarations .....</b>	<b>5-8</b>
<b>Lindsay Rod Anchor and Headed Truss Rod .....</b>	<b>5-9</b>
<b>Non-Towable Drive Tube .....</b>	<b>5-17</b>
<b>Heavy Duty Non-Tow Pivot Assembly.....</b>	<b>5-18</b>
<b>Tower Legs and Stabilizer Angles .....</b>	<b>5-21</b>
<b>Flotation of the Tires on the Soil.....</b>	<b>5-22</b>
<b>Slope/Ridge Limitations.....</b>	<b>5-25</b>

---

*Notes*

## System Dimensions



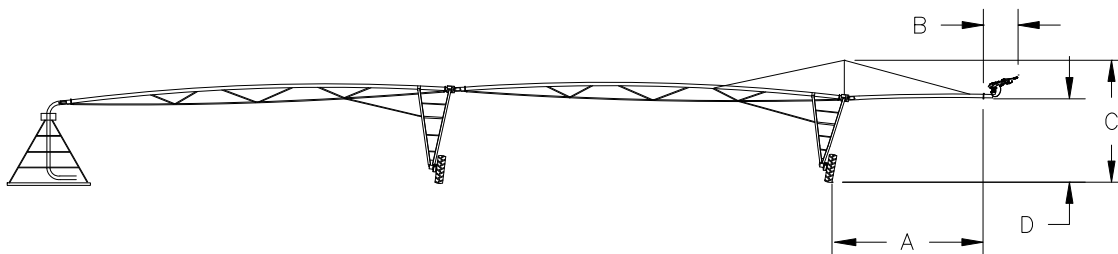
Dimensions will vary due to tire size, terrain and erection procedures. All values are based on a "dry" system.

Pipe Size	Span Length	A	B	C	D	E
10"	113'	13'2"	113'9"	9"	14'	113'
10"	135'	13'2"	135'9"	9'2"	14'2"	135'
8"	113'	12'10"	114'	9'4"	14'4"	113'
8"	135'	12'10"	136'1"	9'7"	14'7"	135'2"
8"	157'	12'10"	158'	9'10"	14'10"	157'
8"	160'	12'10"	161'	9'10"	14'10"	160'
8"	168'	12'10"	169'11"	---	---	168'1"
8"	179'	12'10"	180'2"	9'6"	14'10"	178'11"
8"	180'	12'10"	181'2"	9'6"	14'10"	179'11"
6-5/8"	113'					
6-5/8"	135'	12'10"	136'	9'8"	14'10"	135'
6-5/8"	157'	12'10"	158'1"	9'11"	15'2"	157'1"
6-5/8"	160'	12'10"	161'1"	9'11"	15'2"	160'1"
6-5/8"	168'	12'10"	169'1"	---	---	168'1"
6-5/8"	179'	12'10"	180'2"	9'6"	14'10"	178'11"
6-5/8"	180'	12'10"	181'2"	9'6"	14'10"	179'11"
6-5/8"	186'8"	12'10"	187'10"	---	---	186'7"
6-5/8"	201'	12'10"	202'3"	10'1"	15'1"	201'2"
6-5/8" Z-Tech	113'	12'10"		9'7"	13'6"	113'
6-5/8" Z-Tech	135'	12'10"	136'	9'7"	14'2"	135'
6-5/8" Z-Tech	157'	12'10"	158'1"	10'	14'5"	157'1"
6-5/8" Z-Tech	179'	12'10"	180'2"	10'3"	15'2"	178'11"
5-9/16"	113'					
5-9/16"	135'	12'10"	136'	9'6"	14'7"	135'
5-9/16"	157'	12'10"	158'	9'9"	15'1"	157'6"
5-9/16"	160'	12'10"	161'	---	---	160'6"
5-9/16"	168'	12'10"	169'	---	---	168'6"
5-9/16"	179'	12'10"	180'	9'6"	14'10"	179'
5-9/16"	180'	12'10"	181'	9'6"	14'10"	180'
5-9/16"	201'	--	202'	9'8"	15'0"	201'
Mobile Pivot		13'4"	---	---	---	---

**NOTES**

- F = 12" center line elbow to pad for 8", 6-5/8" & 5-9/16" machines.
- F = 13 1/4" center line elbow to pad for 10" machines.
- F = 39" from ground level to ringlock ring on Mobile Pivot.
- For Low Profile Tower - Deduct 4' from "C" Dimension.
- For High Clearance Tower - Add 3'4" to "C" Dimension.
- For Super High Clearance - Add 7' to "C" Dimension.
- For Mid-Size Pivot Point - Add 3' to "A" Dimension.
- For Tall Pivot - Add 10.75' to "A" Dimension.

**Overhang Lengths**



Dimensions will vary due to tire size, terrain and erection procedures. All values are based on a "dry" system.

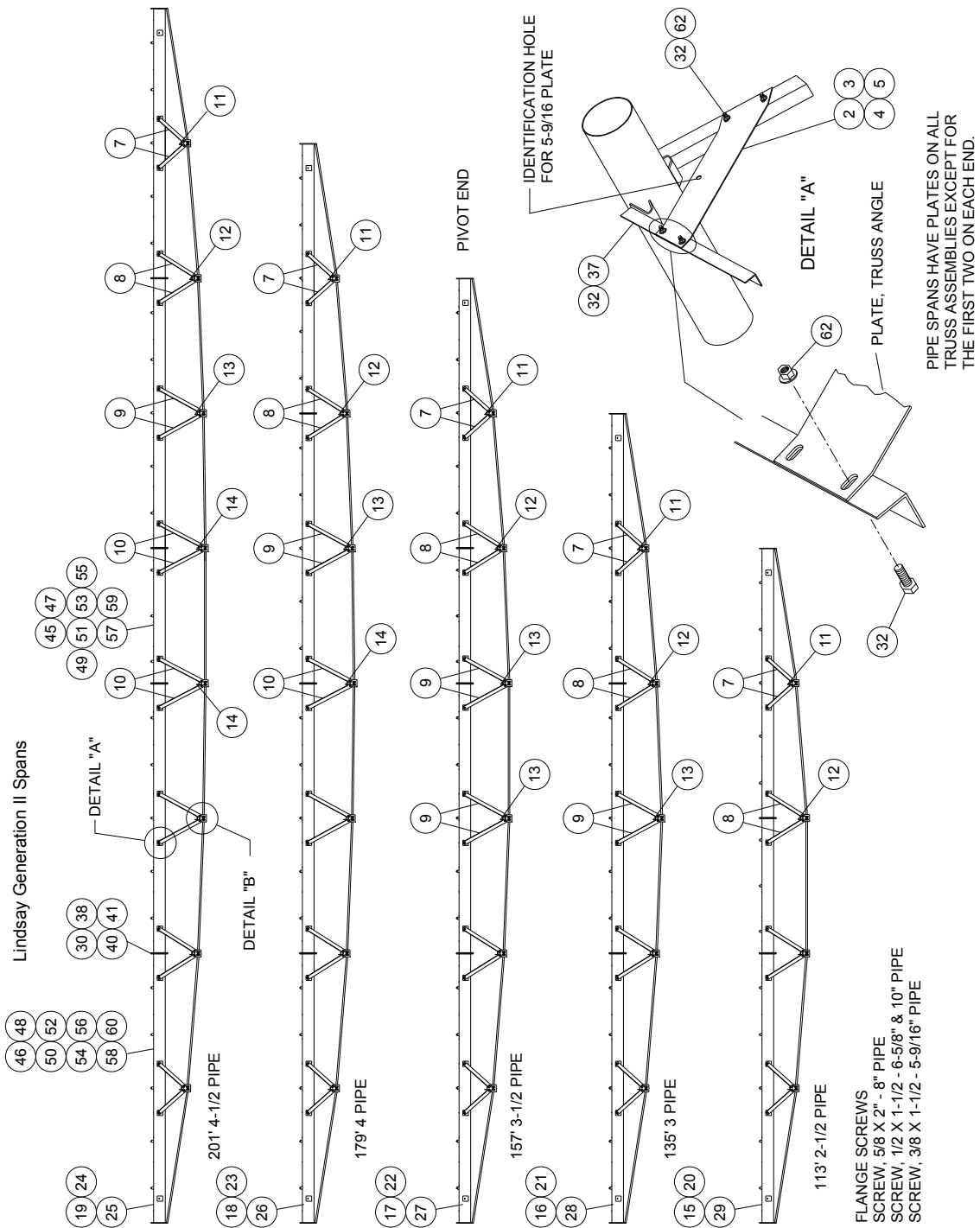
Overhang Length	A	B	C	D
11'	14'		17'6"	11'5"
22'	25'		17'6"	11'5"
33'	36'		17'6"	11'5"
44'	47'		17'6"	11'5"
55'	58'		22'	11'4"
66'	69'		22'	11'4"
88'	91'		22'	11'4"
ST85E End Gun		2'0"		
P100 End Gun		2'4"		
P100 w/Booster Pump		3'0"		

Overhang Length on a Z-Tech Span	A	B	C	D
11'	14'		17'6"	12'4"
22'	25'		17'6"	12'7"
33'	36'		17'6"	12'11"
44'	47'		17'6"	13'5"
55'	58'		22'	13'9"
66'	69'		22'	13'
88'	91'		22'	14'5"
ST85E End Gun		2'0"		
P100 End Gun		2'4"		
P100 w/Booster Pump		3'0"		

---

*Notes*

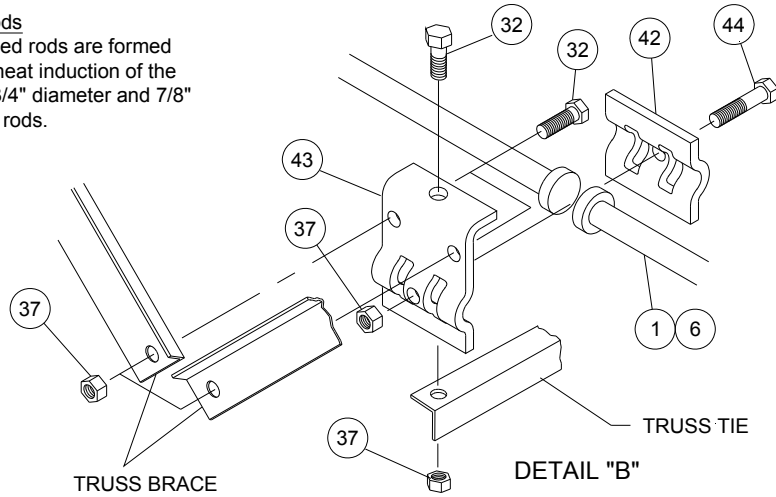
# Domestic Span Configurations



## Lindsay Rod Anchor and Headed Truss Rod

### Truss Rods

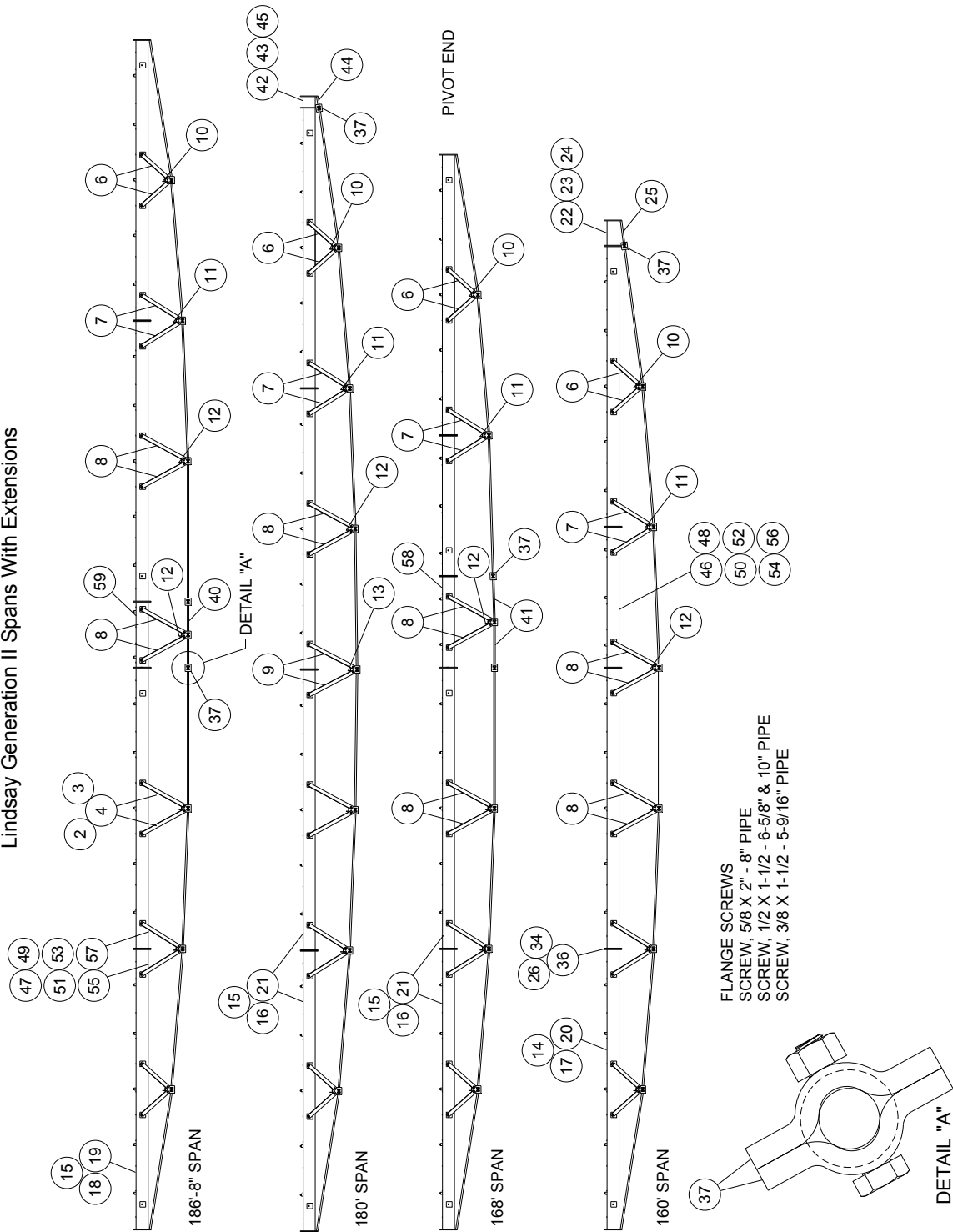
Hot headed rods are formed through heat induction of the ends of 3/4" diameter and 7/8" diameter rods.



Ref.	Part No.	Description	Ref.	Part No.	Description
1	21'-10"	Rod, Truss, Headed, 3/4"	32		Screw, 1/2-13 x 1-1/4", Hex, Gr. 5
2	28-7/8" Base	Plate, Truss Angle, 6-5/8", 1/8" x 5"	33		Screw, 5/8-11 x 2", Hex, Gr. 5
3	28-7/8" Base	Plate, Truss Angle, 5-9/16", 1/8" x 5"	34		Screw, 5/8-11 x 1 1/2", Hex, Gr. 5
4	28-7/8" Base	Plate, Truss Angle, 8", 1/8" x 5"	35		Screw, 3/8-16 x 1", Hex, Gr. 5
5	31-1/2" Base	Plate, Truss Angle, 10", 1/8" x 5"	36		Nut, 5/8-11, Lock
6	21'-9 1/4"	Rod, Truss, Headed, 11/16"	37		Nut, 1/2-13, Lock
7	63-1/2"	Brace, Truss, 2" x 2" x 3/16"	38		Gasket, Flange, Zimmatic, 5-9/16"
8	81-1/4"	Brace, Truss, 2" x 2" x 1/8"	39		Nut, 3/8-16, Flange, Toplock
9	97-3/4"	Brace, Truss, 2" x 2" x 1/8"	40		Gasket, 6-5/8", Pipe Flange
10	101-3/4"	Brace, Truss, 2" x 2" x 1/8"	41		Gasket, 10", Pipe Flange
11	62-1/8"	Tie, Truss, 1-1/2" x 1-1/2" x 1/8"	42		Anchor, Rod, 2 Pc, w/o Holes
12	95-1/8"	Tie, Truss, 1-1/2" x 1-1/2" x 1/8"	43		Anchor, Rod, 2 Pc, w/ Holes
13	123-1/8"	Tie, Truss, 2" x 2" x 1/8"	44		Screw, 1/2-13 x 2-1/4", Hex, Gr. 5
14	129-1/8"	Tie, Truss, 1-1/2" x 1-1/2" x 1/8"	45	22'-0"	Pipe, Half, 6-5/8", Formed Outlet
15	118.5'	Cable, Elec., 4#10, 6#14	46	44'-0"	Pipe, Span, 6-5/8", Formed Outlet
16	140.5'	Cable, Elec., 4#10, 6#14	47	22'-0"	Pipe, Half, 5-9/16", Formed Outlet
17	162.5'	Cable, Elec., 4#10, 6#14	48	44'-0"	Pipe, Span, 5-9/16", Formed Outlet
18	184.5'	Cable, Elec., 4#10, 6#14	49	22'-0"	Pipe, Half, 8", 90" Outlets
19	206.5'	Cable, Elec., 4#10, 6#14	50	44'-0"	Pipe, Span, 8", 90" Outlets
20	118.5'	Cable, Elec., 4#12, 6#14	51	22'-0"	Pipe, Half, 10", 90" Outlets
21	140.5'	Cable, Elec., 4#12, 6#14	52	44'-0"	Pipe, Span, 10", 90" Outlets
22	162.5'	Cable, Elec., 4#12, 6#14	53	22'-0"	Pipe, Half, 6-5/8", 30" Outlets
23	184.5'	Cable, Elec., 4#12, 6#14	54	44'-0"	Pipe, Span, 6-5/8", 30" Outlets
24	206.5'	Cable, Elec., 4#12, 6#14	55	22'-0"	Pipe, Half, 5-9/16", 30" Outlets
25	206.5'	Cable, Elec., 4#14, 6#18	56	44'-0"	Pipe, Span, 5-9/16", 30" Outlets
26	184.5'	Cable, Elec., 4#14, 6#18	57	22'-0"	Pipe, Half, 8", 30" Outlets
27	162.5'	Cable, Elec., 4#14, 6#18	58	44'-0"	Pipe, Span, 8", 30" Outlets
28	140.5'	Cable, Elec., 4#14, 6#18	59	22'-0"	Pipe, Half, 10", 30" Outlets
29	118.5'	Cable, Elec., 4#14, 6#18	60	44'-0"	Pipe, Span, 10", 30" Outlets
30		Gasket, Flange, 8"	61		Screw, 1/2-13 x 1-1/2", Hex, Gr. 5
31		Screw, 3/8-16 x 1-1/2", Hex, Gr. 5	62		Nut, 1/2-13, Flng, T. LK, Gr. A, ZN

# Domestic Span Configurations

Lindsay Generation II Spans With Extensions

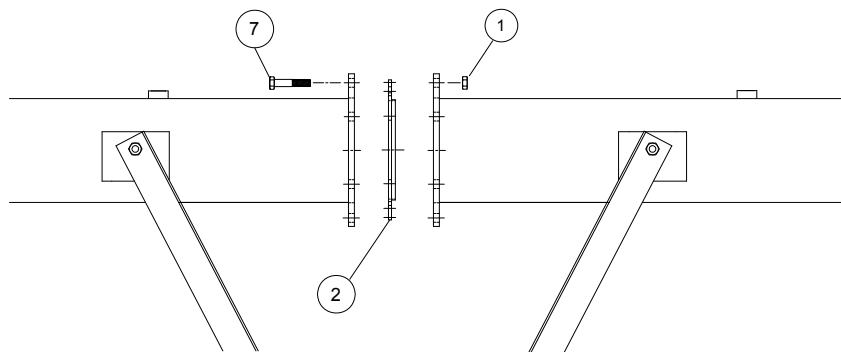
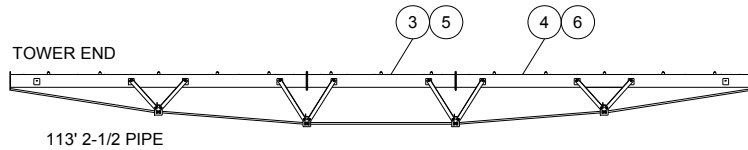
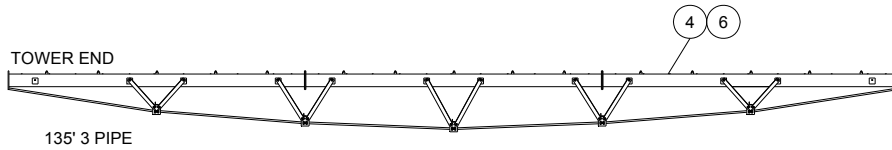
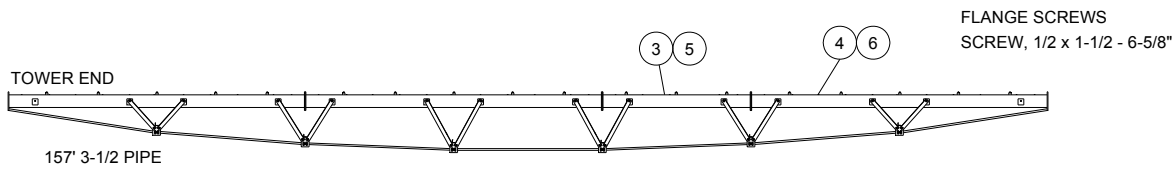
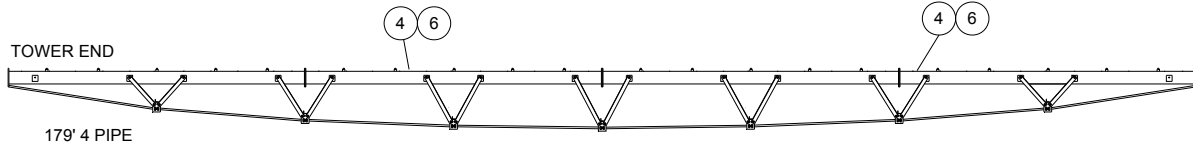
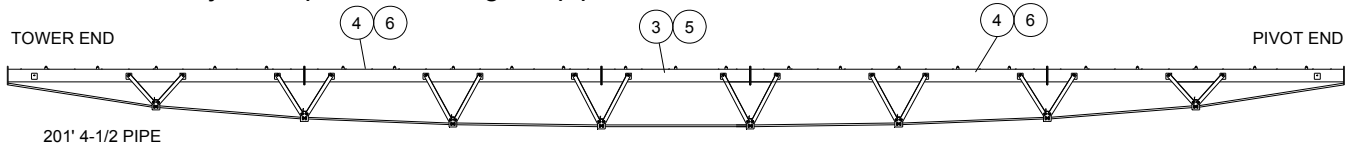


Ref.	Part No.	Description
1	21'-10"	Rod, Truss, Headed, 3/4"
2	28-7/8" Base	Plate, Truss Angle, 6-5/8", 1/8" x 5"
3	28-7/8" Base	Plate, Truss Angle, 5-9/16", 1/8" x 5"
4	28-7/8" Base	Plate, Truss Angle, 8", 1/8" x 5"
5	21'-9 1/4"	Rod, Truss, Headed, 11/16"
6	63-1/2"	Brace, Truss, 2" x 2" x 3/16"
7	81-1/4"	Brace, Truss, 2" x 2" x 1/8"
8	97-3/4"	Brace, Truss, 2" x 2" x 1/8"
9	101-3/4"	Brace, Truss, 2" x 2" x 1/8"
10	62-1/8"	Tie, Truss, 1-1/2" x 1-1/2" x 1/8"
11	95-1/8"	Tie, Truss, 1-1/2" x 1-1/2" x 1/8"
12	123-1/8"	Tie, Truss, 2" x 2" x 1/8"
13	129-1/8"	Tie, Truss, 1-1/2" x 1-1/2" x 1/8"
14	171'	Cable, Elec., 4#10, 6#14
15	193'	Cable, Elec., 4#10, 6#14
16	184.5'	Cable, Elec., 4#12, 6#14
17	171"	Cable, Elec., 4#12, 6#14
18	193'	Cable, Elec., 4#12, 6#14
19	193"	Cable, Elec., 4#14, 6#18
20	171'	Cable, Elec., 4#14, 6#18
21	184.5'	Cable, Elec., 4#14, 6#18
22	36"	Pipe Weld, 6-5/8" Span Ext.
23	36"	Pipe Weld, 5-9/16" Span Ext.
24	36"	Pipe Weld, 8" Span Ext.
25	36"	Rod, Truss, Headed, 7/8" Ext.
26		Gasket, Flange, 8"
27		Screw, 3/8-16 x 1-1/2", Hex, Gr. 5
28		Screw, 1/2-13 x 1-1/4", Hex, Gr. 5
29		Screw, 5/8-11 x 2", Hex, Gr. 5
30		Screw, 5/8-11 x 1 1/2", Hex, Gr. 5

Ref.	Part No.	Description
31		Screw, 3/8-16 x 1", Hex, Gr. 5
32		Nut, 5/8-11, Lock
33		Nut, 1/2-13, Lock
34		Gasket, Flange, Zimmatic, 5-9/16"
35		Nut, 3/8-16, Flange, Toplock
36		Gasket, 6-5/8", Pipe Flange
37		Anchor, Rod, 2 Pc, w/o Holes
38		Anchor, Rod, 2 Pc, w/ Holes
39		Screw, 1/2-13 x 2-1/4", Hex, Gr. 5
40	42-3/4"	Rod, Truss, Headed, 7/8"
41	63"	Rod, Truss, Headed, 7/8"
42	12"	Pipe Weld, 6-5/8" Span Ext.
43	12"	Pipe Weld, 5-9/16" Span Ext.
44	9-3/4"	Rod Weldment, Headed, 7/8"
45	12"	Pipe Weld, 8" Span Ext.
46	22'-0"	Pipe, Half, 6-5/8", Formed Outlet
47	44'-0"	Pipe, Span, 6-5/8", Formed Outlet
48	22'-0"	Pipe, Half, 5-9/16", Formed Outlets
49	44'-0"	Pipe, Span, 5-9/16", Formed Outlets
50	22'-0"	Pipe, Half, 8", 90" Outlets
51	44'-0"	Pipe, Span, 8", 90" Outlets
52	22'-0"	Pipe, Half, 6-5/8", 30" Outlets
53	44'-0"	Pipe, Span, 6-5/8", 30" Outlets
54	22'-0"	Pipe, Half, 5-9/16", 30" Outlets
55	44'-0"	Pipe, Span, 5-9/16", 30" Outlets
56	22'-0"	Pipe, Half, 8", 30" Outlets
57	44'-0"	Pipe, Span, 8", 30" Outlets
58	11'	Pipe, 6-5/8" Extension
59	7'-8"	Pipe, 6-5/8" Extension
60		Screw, 1/2-13 x 1-1/2", Hex, Gr. 5
61		Nut, 1/2-13, Flng, T. LK, Gr. A, ZN

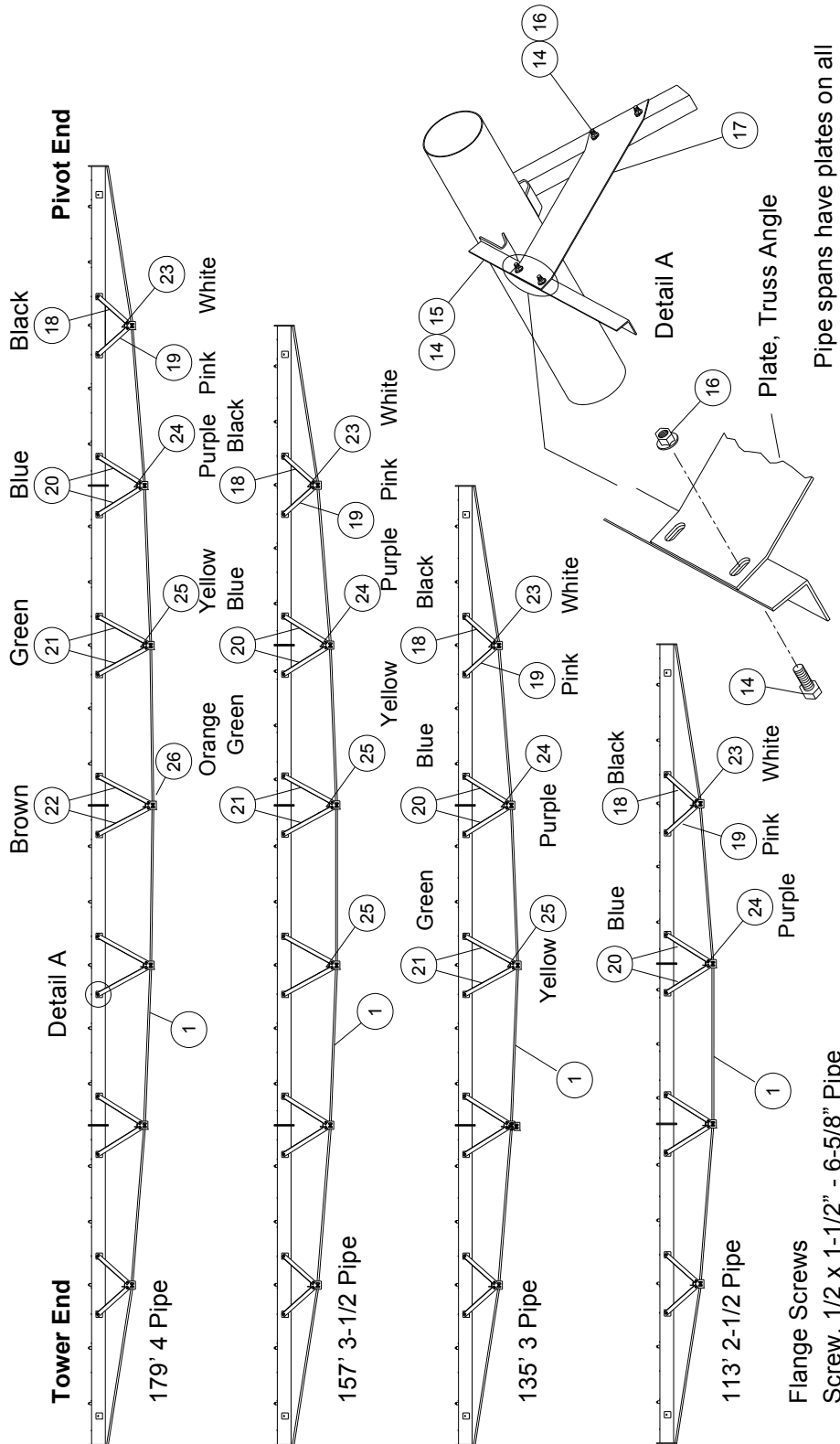
## Span Assembly (Pipe Identification) Z-Tech

**NOTE:** While lifting the span to assemble tower, place the span strap next to joint to prevent damage to pipe.



Ref.	Part No.	Description
1	6-2418-9	Nut, 1/2-13, Lock
2	6-4486-4	Gasket, 6-5/8", Pipe Flange
3	13-3057-0	Pipe, Half, 6-5/8", 90" Outlets, 12 Ga.
4	13-3058-0	Pipe, Span, 6-5/8", 90" Outlets, 12 Ga.
5	13-3059-0	Pipe, Half, 6-5/8", 30" Outlets, 12 Ga.
6	13-3060-0	Pipe, Span, 6-5/8", 30" Outlets, 12 Ga.
7	26-0760-4	Screw, 1/2-13 x 1-1/2", Hex, Gr. 5

# Span Assembly (Truss Assembly), Z-Tech



Pipe spans have plates on all truss assemblies except for the first two on each end.

**NOTES:** Inside truss on first v-jack on 179', 157', 135' and 113' span is 60". Outside truss on first v-jack is 61-1/2"

Make sure spans are not tilted when tightening bolts. If there is a tilt to the span, loosen bolts, level span, and re-tighten bolts.

While lifting the span to assemble tower, place the span strap next to joint to prevent damage to pipe.

## Span Assembly (Truss Assembly), Z-Tech (cont'd.)

**Electrical Cable Lengths**

Span Lengths	Cable Lengths
179'	184.5
157'	162.5
135'	140.5
113'	118.5

**International Electrical Cable Lengths**  
(Non-Shielded Cable)

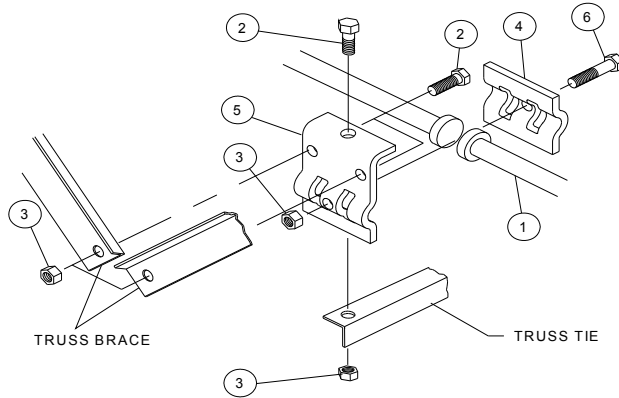
Part Number	Span Lengths	Cable Lengths
3-8170-7	179'	184.5
3-8171-5	157'	162.5
3-8172-3	135'	140.5
3-8173-1	113'	118.5

Ref.	Part No.	Description
1	3-0337-0	Rod, Truss, Headed, 11/16"
2	3-6917-3	Cable, Elec., 4#10, 6#14, 118.5'
3	3-6918-1	Cable, Elec., 4#10, 6#14, 140.5'
4	3-6919-9	Cable, Elec., 4#10, 6#14, 162.5'
5	3-6920-7	Cable, Elec., 4#10, 6#14, 184.5'
6	3-6927-2	Cable, Elec., 4#12, 6#14, 118.5'
7	3-6928-0	Cable, Elec., 4#12, 6#14, 140.5'
8	3-6929-8	Cable, Elec., 4#12, 6#14, 162.5'
9	3-6930-6	Cable, Elec., 4#12, 6#14, 184.5'
10	3-8141-8	Cable, Elec., 4#14, 6#18, 184.5'
11	3-8142-6	Cable, Elec., 4#14, 6#18, 162.5'
12	3-8143-4	Cable, Elec., 4#14, 6#18, 140.5'
13	3-8144-2	Cable, Elec., 4#14, 6#18, 118.5'

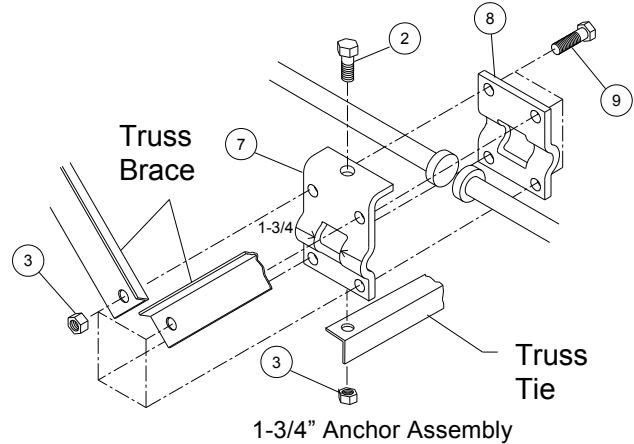
Ref.	Part No.	Description
14	6-0804-2	Screw, 1/2-13 x 1-1/4", Hex, Gr. 5
15	6-2418-9	Nut, 1/2-13, Lock
16	11-4529-1	Nut, 1/2-13, Flange, Toplock
17	13-5355-0	Plate, Truss Angle, 6-5/8"
18	13-5356-0	Brace, Truss, 61-1/2", Black
19	13-5357-0	Brace, Truss, 60", Pink
20	13-5362-0	Brace, Truss, 75-1/2", Blue
21	13-5363-0	Brace, Truss, 86-1/2", Green
22	13-5364-0	Brace, Truss, 90-1/2", Brown
23	13-5365-0	Tie, Truss, 57-5/8", White
24	13-5366-0	Tie, Truss, 87", Purple
25	13-5367-0	Tie, Truss, 108 3/8", Yellow
26	13-5368-0	Tie, Truss, 114-3/4", Orange

## Rod Pockets, Z-Tech

### Standard Rod Pockets - Position A



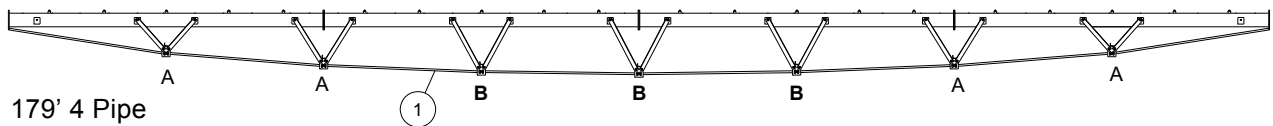
### Short Rod Pockets - Position B



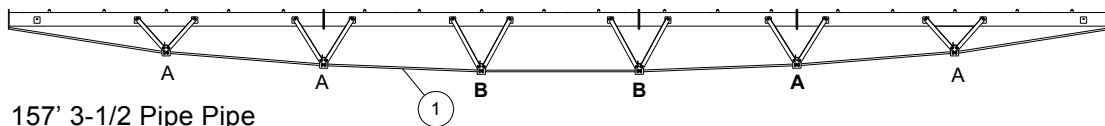
While suspending the span during erection, align the rod anchors before tightening to allow a box wrench to fit onto the screw head when tightening the truss screw.

**Tower End**

**Pivot End**



179' 4 Pipe



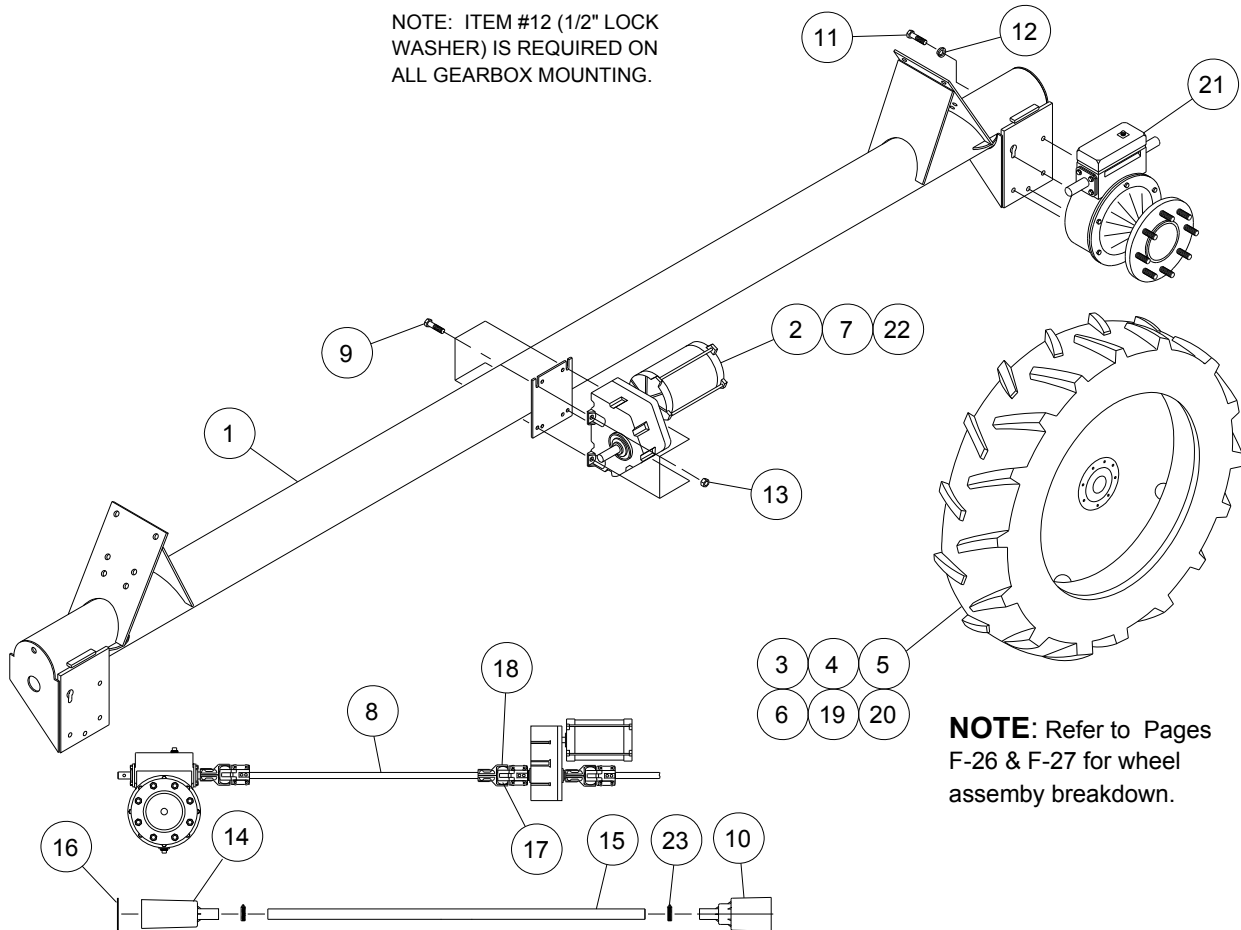
157' 3-1/2 Pipe Pipe

**NOTE:** 113' and 135' use standard rod pockets.

Ref.	Part No.	Description
1	3-0337-0	Rod, Truss, Headed, 11/16"
2	6-0804-2	Screw, 1/2-13 x 1-1/4", Hex, Gr. 5
3	6-2418-9	Nut, 1/2-13, Lock
4	10-5892-4	Anchor, Rod, 2 Pc, w/o Holes
5	10-5893-2	Anchor, Rod, 2 Pc, w/Holes
6	10-5894-0	Screw, 1/2-13 x 2-1/4", Hex, Gr. 5
7	12-2660-0	Anchor, Rod, Top, 1-3/4" I.D.
8	12-2661-0	Anchor, Rod, Bottom, 1-3/4" I.D.
9	26-0760-4	Screw, 1/2-13 x 1-1/2", Hex, Gr. 5

## Drive Tube Assembly, Non-Towable

NOTE: ITEM #12 (1/2" LOCK WASHER) IS REQUIRED ON ALL GEARBOX MOUNTING.



NOTE: Refer to Pages F-26 & F-27 for wheel assembly breakdown.

Ref.	Original Part No.	Substitute Part No.	Description
1	03-0758-7		Frame, Drive Tube, Solid Mount
2	03-4184-2		Motor Assy, 3/4 HP, 43 RPM
3	03-4840-9		Wheel Assy, 11.2 x 24", Right
4	03-4841-7		Wheel Assy, 11.2 x 24", Left
5	03-4842-5		Wheel Assy, 14.9 x 24, Right
6	03-4843-3		Wheel Assy, 14.9 x 24, Left
7	03-4984-5		Motor Assembly, 1 HP, 30 RPM
8	04-0716-3		Shaft, Drive, 7/8", 59-1/4"
9	06-3415-4		Screw, 3/8-16 x 1-1/4" Hex, Gr. 5
10	06-3589-6		Bell, Drive Shaft End
11	06-0804-2		Screw, 1/2-13 x 1-1/4", Hex, Gr. 5
12	06-0814-1		Washer, Lock, 1/2"

Ref.	Original Part No.	Substitute Part No.	Description
13	06-3419-6		Nut, 3/8-16, Hex, Flange
14	06-4378-3		Bell, Drive Shaft End
15	06-4442-7		Tube, Drive Shaft, 1-1/2" x 54"
16	06-4590-3		Washer, Drive Shaft Bell
17	10-0433-2		Insert, Drive Shaft Coupler
18	10-0435-7		Coupler, Kit, 7/8" Drive Shaft
19	11-5491-3		Wheel Assy, 11 x 22.5, R, Recap
20	11-5492-1		Wheel Assy, 11 x 22.5, L, Recap
21	11-8409-0		Gearbox, PowerDrive, Non-Tow
22	12-5327-0		Motor Assy, Lind. CD, 1 HP, 59 RPM
23	26-1091-3		Clamp, Hose, Worm Drive

## Heavy Duty Non-Tow Pivot Assembly, 8", 6-5/8", 5-9/16"

NOTE: COAT THE PIVOT ELL WITH GREASE BEFORE INSTALLING THE PIVOT ELL INTO THE HEAD. AFTER INSTALLING THE PIVOT ELL INTO THE PIVOT HEAD, PUMP ANOTHER TUBE OF GREASE INTO THE PIVOT HEAD USING A TOTAL OF TWO TUBES OF GREASE.

ON 8" STAINLESS STEEL PIVOTS, USE 11-6157-9, RISER WELDMENT, PIVOT, STAINLESS STEEL, IN PLACE OF ITEM #2.

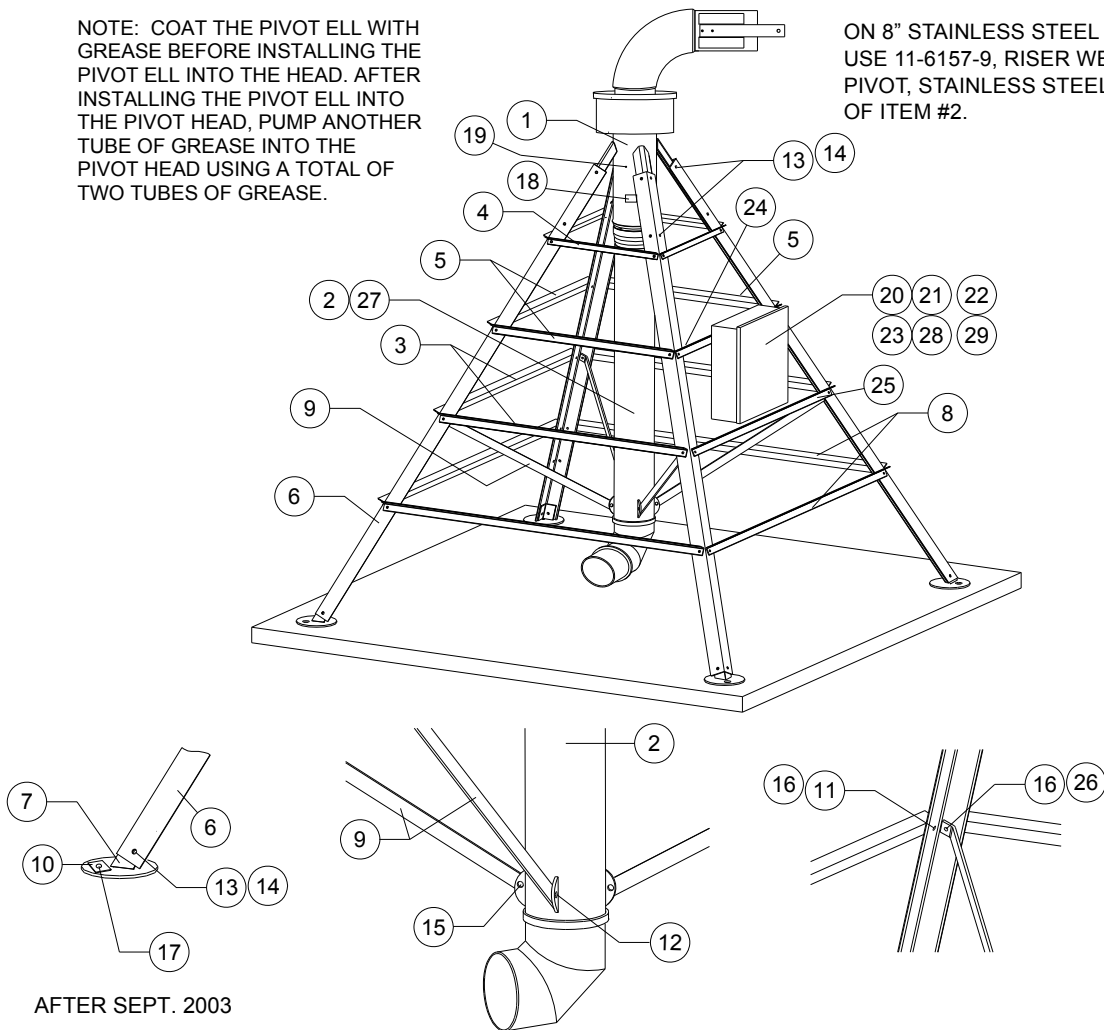
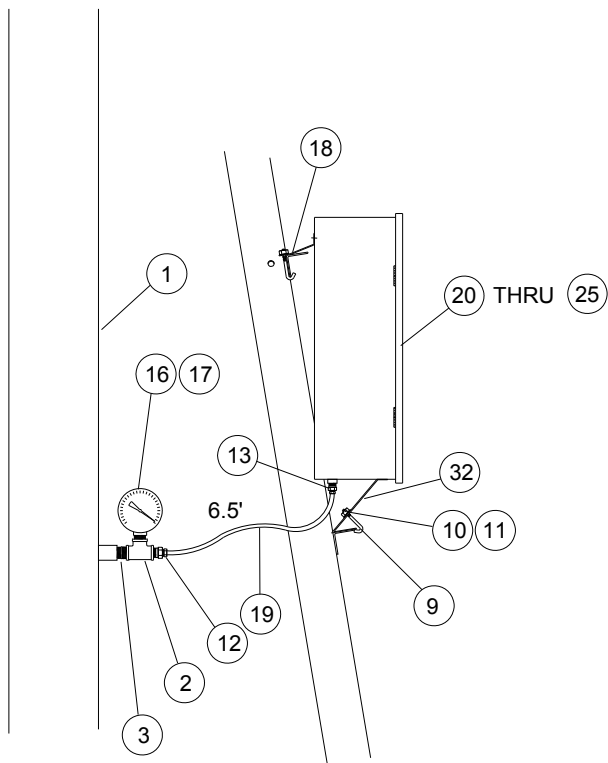
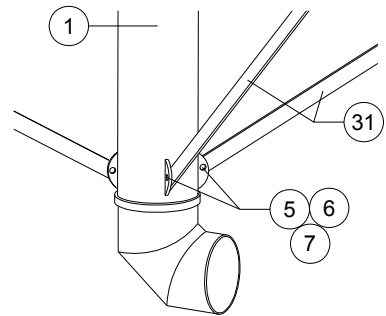
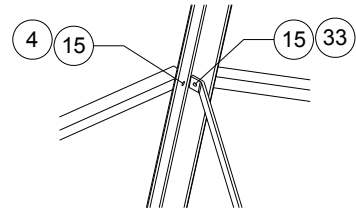
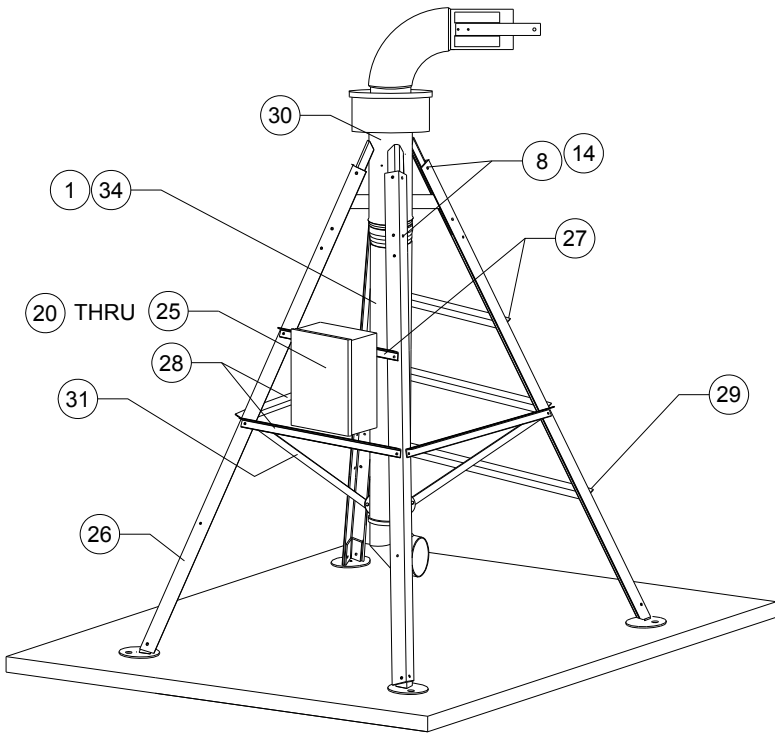


Figure 5.1

Ref.	Part No.	Description
1	3-0030-1	Head Weldment, Pivot
2	3-0070-7	Riser Weldment, Pivot
3	3-0810-6	Tie, Pivot, 2nd From Bottom
4	3-0830-4	Tie, Pivot, Top
5	3-1110-0	Brace, Truss Side, 51-1/2"
6	3-4600-7	Leg, Heavy Duty, Pivot
7	3-4772-4	Anchor Weldment, Pivot, Non-Tow
8	3-6939-7	Tie, Pivot Bottom, 92"
9	4-0063-0	Strap, Pivot Riser
10	4-4775-5	Washer, Rectangle, 15/16" x 2-1/2 x 3"
11	6-0804-2	Screw, 1/2-13 x 1-1/4", Hex, Gr.5
12	6-0809-1	Screw, 3/4-10 x 2", Hex, Gr.5
13	6-0839-8	Screw, 5/8-11 x 1-1/2", Hex, Gr. 5
14	6-2416-3	Nut, 5/8-11, Lock
15	6-2417-1	Nut, 3/4-10, Lock

Ref.	Part No.	Description
16	6-2418-9	Nut, 1/2-13, Lock
17	11-0024-7	Nut, 7/8-9, Lock, Nylon Insert
18	11-0046-0	Decal, "Grease"
19	11-0470-2	Zerk, 5/16", Drive-In
20	11-7827-6	Panel, FieldBOSS, 480 Volt
21	11-7829-2	Panel, FieldBOSS, 380 Volt, CE
22	11-8391-0	Panel, FieldBASIC, 480 Volt
23	11-8393-0	Panel, FieldBASIC, 380 Volt, CE
24	11-9461-0	Tie, Pivot, Panel Mount, Top
25	11-9462-0	Tie, Pivot, Panel Mount, Bottom
26	26-0760-4	Screw, 1/2-13 x 1-1/2", Hex, Gr. 5
27	11-6157-9	Riser Weld., Pivot, Stainless Steel
28	13-3634-0	Panel, FieldVISION, 480V
29	13-5533-0	Panel, FieldVISION, 380V, CE

**Non-Tow Pivot Assembly, 6-5/8", 5-9/16", Compact Pivot**  
**Non-Tow Pivot Assembly, 5-9/16", Compact Pivot, Stainless Steel**



**NOTE:** Be sure to mount panel as shown.

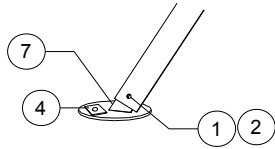
**Non-Tow Pivot Assembly, 6-5/8", 5-9/16", Compact Pivot**  
**Non-Tow Pivot Assembly, 5-9/16", Compact Pivot, Stainless Steel**

Ref.	Original Part No.	Description
1	3-0070-7	Riser, Pivot
2	6-0649-1	Tee, Pipe, 1/4"
3	6-0652-5	Nipple Pipe, 1/4 x 2
4	6-0804-2	Screw, 1/2-13 x 1-1/4", Hex, Gr. 5
5	6-0809-1	Screw, 3/4-10 x 2", Hex, Gr. 5
6	6-0816-6	Washer, Lock, 3/4"
7	6-0826-5	Nut, 3/4-10, Hex
8	6-0839-8	Screw, 5/8-11 x 1-1/2", Hex, Gr. 5
9	6-0840-6	Bolt, 1/4-20 x 2-1/2, J
10	6-0841-4	Nut, 1/4-20, Hex
11	6-0842-2	Washer, Flat, 1/4"
12	6-0956-0	Connector, Hose, 1/4" x 1/4" MPT
13	6-2159-9	Connector, Hose, 1/4" x 1/8" MPT
14	6-2416-3	Nut, 5/8-11, Lock
15	6-2418-9	Nut, 1/2-13, Lock
16	6-3343-8	Gauge, Pres., Liq-Filled, 0-160
17	6-4715-6	Gauge, Pres., Liq-Filled, 0-100
18	10-3475-0	Panel, Mount, Top
19	11-3531-8	Tubing, Plas., 1/4"OD x .040" Wall
20	11-7827-6	Panel, FieldBOSS, 480 Volt
21	11-7829-2	Panel, FieldBOSS, 380 Volt, CE
22	11-8391-0	Panel, FieldBASIC, 480V

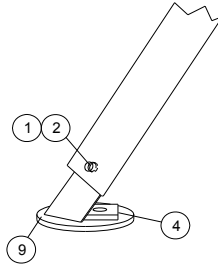
Ref.	Original Part No.	Description
23	11-8393-0	Panel, FieldBASIC, 380 Volt, CE
24	13-3634-0	Panel, FieldVISION, 480V
25	13-5533-0	Panel, FieldVISION, 380V, CE
26	13-5727-0	Leg, Pivot, 10"
27	13-5859-0	Brace, Truss Side, 40-1/2"
28	13-5860-0	Tie, Pivot, 2nd fm Bottom, 55-1/2"
29	13-5861-0	Tie, Truss, 70"
30	13-5725-0	Head Weldment, Pivot
31	13-5862-0	Strap, Pivot Riser
32	13-6473-0	Bracket, Panel Mount, Bottom
33	26-0760-4	Screw, 1/2-13 x 1-1/2", Hex, Gr. 5
34	11-6157-9	Riser, Pivot, Stainless Steel

## Foot Options, Compact Pivot

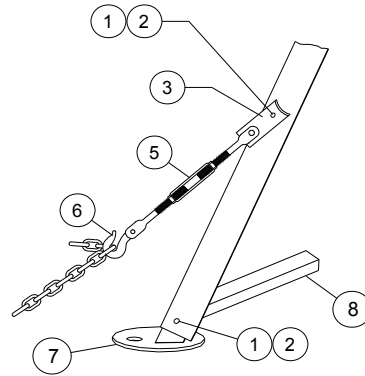
(Pivot Foot not interchangeable with Gen II standard pivot point)



84.5" Spacing bolt pattern



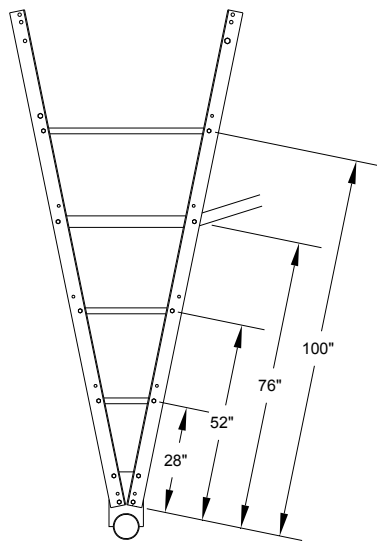
78" Spacing bolt pattern



Chain Tie Down Option

Ref.	Part No.	Description
1	6-0839-8	Screw, 5/8-11 x 1-1/2", Hex, Gr. 5
2	6-2416-3	Nut, 5/8-11, Lock
3	4-2776-5	Bracket, Pivot Leg
4	4-4775-5	Washer, Rectangle, 15/16"x2-1/2x3"
5	6-0011-4	Turnbuckle, 3/4 x 6 Clev.End,w/Pin
6	6-2382-7	Hook, Eye Grab, 1/2"
7	13-5807-0	Anchor, Pivot, Non-Tow
8	13-9497-0	Angle, Bottom, Pivot
9	13-9871-0	Anchor Weldment, Pivot

## Tower Legs and Stabilizer Angles



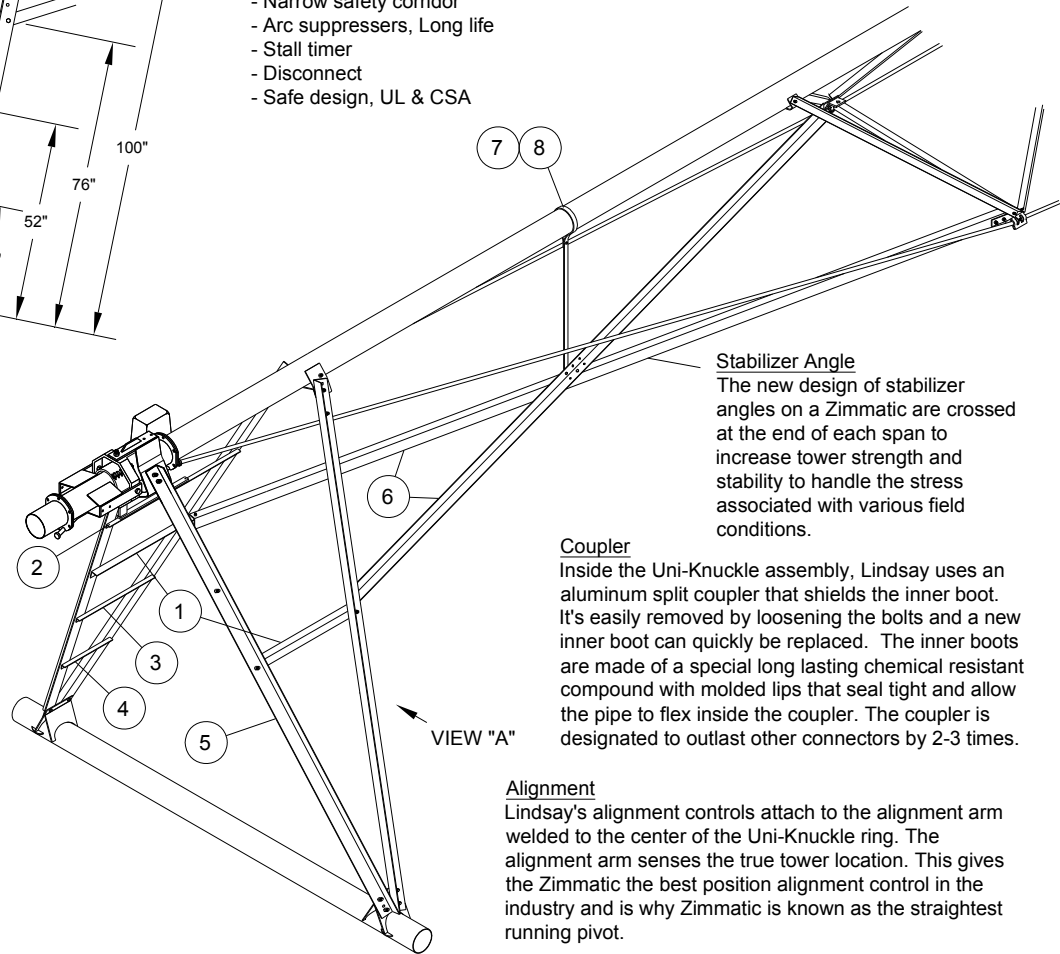
VIEW "A"

### Span Connection

The Lindsay span connection is the patented Uni-Knuckle which allows stress-free flexing of each span. It is outside the pipe, so there is no water restriction. This heavy duty Uni-Knuckle is held in place by 4 bolts at 4 connection points.

### Tower Box

- Narrow safety corridor
- Arc suppressers, Long life
- Stall timer
- Disconnect
- Safe design, UL & CSA



VIEW "A"

### Stabilizer Angle

The new design of stabilizer angles on a Zimmatic are crossed at the end of each span to increase tower strength and stability to handle the stress associated with various field conditions.

### Coupler

Inside the Uni-Knuckle assembly, Lindsay uses an aluminum split coupler that shields the inner boot. It's easily removed by loosening the bolts and a new inner boot can quickly be replaced. The inner boots are made of a special long lasting chemical resistant compound with molded lips that seal tight and allow the pipe to flex inside the coupler. The coupler is designated to outlast other connectors by 2-3 times.

### Alignment

Lindsay's alignment controls attach to the alignment arm welded to the center of the Uni-Knuckle ring. The alignment arm senses the true tower location. This gives the Zimmatic the best position alignment control in the industry and is why Zimmatic is known as the straightest running pivot.

Ref.	Part No.	Description
1	3-0513-6	Tie, Tower, Stabilizer Attachment, 3" x 3" x 3/16"
2	3-2344-4	Tie, Tower, Top, 1-1/2" x 1-1/2" x 1/8"
3	3-2346-9	Tie, Tower, 2nd from Bottom, 1-1/2" x 1-1/2" x 1/8"
4	3-2347-7	Tie, Tower, Bottom, 1-1/2" x 1-1/2" x 1/8"
5	3-6741-7	Leg, Tower, 4" x 4" x 1/4"
6	3-6743-3	Angle, Stabilizer, 3" x 3" x 3/16"
7	3-6749-0	Support, Stabilizer, 5-9/16"
8	3-6749-0	Support, Stabilizer, 6-5/8"

## Flotation of the Tires on the Soil

Pipe Size	WET *Span Weight w/Std. Tower	Tire Size	**Ground Pressure (PSI) Std. Towers	**Ground Pressure (PSI) Medium Towers	**Ground Pressure (PSI) High Towers
10" - 113'	7,554	11.2 x 24	15.6	---	---
		11.2 x 38	11.8	---	---
		14.9 x 24	11.8	---	---
		16.9 x 24	7.09	---	---
		Z-Trax	4.3	---	---
10" - 135'	8,630	11.2 x 24	17.8	---	---
		11.2 x 38	13.5	---	---
		14.9 x 24	13.5	---	---
		16.9 x 24	8.1	---	---
		Z-Trax	4.8	---	---
8" - 113'	5,735	11.2 x 24	11.8	12.0	12.5
		11.2 x 38	9.0	9.2	9.5
		14.9 x 24	9.0	9.2	9.5
		16.9 x 24	5.4	5.5	5.7
		Z-Trax	3.4	---	---
8" - 135'	6,635***	11.2 x 24	13.4	13.6	14.1
		11.2 x 38	10.1	10.3	10.6
		14.9 x 24	10.1	10.3	10.6
		16.9 x 24	6.1	6.2	6.4
		Z-Trax	3.7	---	---
8" - 157'	7,165	11.2 x 24	14.8	15.0	15.5
		11.2 x 38	11.2	11.4	11.7
		14.9 x 24	11.2	11.4	11.7
		16.9 x 24	6.7	6.8	7.0
		Z-Trax	4.1	---	---
8" - 160'	8,065***	11.2 x 24	15.5	15.7	16.2
		11.2 x 38	11.7	11.9	12.2
		14.9 x 24	11.7	11.9	12.2
		16.9 x 24	7.0	7.1	7.3
		Z-Trax	4.3	---	---
8" - 168'	7,781	11.2 x 24	16.1	16.3	16.8
		11.2 x 38	12.2	12.4	12.7
		14.9 x 24	12.2	12.4	12.7
		16.9 x 24	7.3	7.4	7.6
		Z-Trax	4.4	---	---
8" - 179'	8,256	11.2 x 24	16.1	16.3	16.7
		11.2 x 38	12.2	12.4	12.7
		14.9 x 24	12.2	12.4	12.7
		16.9 x 24	7.3	7.4	7.6
		Z-Trax	4.6	---	---
	9,156***				

\* For Medium Clearance Towers add 103 lbs and for High Clearance towers add 322 lbs.

\*\* Contact areas and ground pressure based on manufacturer's data at recommended load and inflation.  
(Based on 3" penetration)

\*\*\*Additional span weight based on 900 lbs. per span for two Z-Trax.

## Flotation of the Tires on the Soil

Pipe Size	WET *Span Weight w/Std. Tower	Tire Size	**Ground Pressure (PSI) Std. Towers	**Ground Pressure (PSI) Medium Towers	**Ground Pressure (PSI) High Towers
8" - 186' 8"	8,548	11.2 x 24	17.7	---	---
		11.2 x 38	13.4	---	---
		14.9 x 24	13.4	---	---
		16.9 x 24	8.0	---	---
	9,448***	Z-Trax	4.8	---	---
6-5/8" - 135'	5,380	11.2 x 24	11.1	11.3	11.8
		11.2 x 38	8.4	8.6	8.9
		14.9 x 24	8.4	8.6	8.9
		16.9 x 24	5.0	5.1	5.3
	6,280***	Z-Trax	3.2	---	---
6-5/8" - 157'	6,050	11.2 x 24	12.5	12.7	13.2
		11.2 x 38	9.5	9.7	10.0
		14.9 x 24	9.5	9.7	10.0
		16.9 x 24	5.7	5.8	6.0
	6,950***	Z-Trax	3.5	---	---
6-5/8" - 160'	6,128	11.2 x 24	12.7	12.9	13.4
		11.2 x 38	9.6	9.8	10.1
		14.9 x 24	9.6	9.8	10.1
		16.9 x 24	5.7	5.8	6.0
	7,028***	Z-Trax	3.6	---	---
6-5/8" - 168'	6,385	11.2 x 24	13.2	13.4	13.9
		11.2 x 38	10.0	10.2	10.5
		14.9 x 24	10.0	10.2	10.5
		16.9 x 24	6.0	6.1	6.3
	7,285***	Z-Trax	3.7	---	---
6-5/8" - 179'	6,920	11.2 x 24	14.3	14.5	15.0
		11.2 x 38	10.8	11.0	11.3
		14.9 x 24	10.8	11.0	11.3
		16.9 x 24	6.5	6.6	6.8
	7,820***	Z-Trax	4.0	---	---
6-5/8" - 186'8"	7,106	11.2 x 24	14.7	14.9	15.4
		11.2 x 38	11.1	11.3	11.6
		14.9 x 24	11.1	11.3	11.6
		16.9 x 24	6.7	6.8	7.0
	8,006***	Z-Trax	4.1	---	---
6-5/8" - 201'	7,700	11.2 x 24	15.9	---	---
		11.2 x 38	12.0	---	---
		14.9 x 24	12.0	---	---
		16.9 x 24	7.2	---	---
	8,600***	Z-Trax	4.4	---	---

\* For Medium Clearance Towers add 103 lbs and for High Clearance towers add 322 lbs.

\*\* Contact areas and ground pressure based on manufacturers data at recommended load and inflation.  
(Based on 3" penetration)

\*\*\*Additional span weight based on 900 lbs. per span for two Z-Trax.

## Flotation of the Tires on the Soil

Pipe Size	Wet *Span Weight w/Std. Tower	Tire Size	**Ground Pressure (PSI) Std. Towers	**Ground Pressure (PSI) Medium Towers	**Ground Pressure (PSI) High Towers
6-5/8" - 135', Z-Tech	5139	11.2 x 24	10.6	10.8	11.3
		11.2 x 38	8.0	8.2	8.5
		14.9 x 24	8.0	8.2	8.5
		16.9 x 24	4.8	4.9	5.1
		Z-Trax	3.1	---	---
6-5/8" - 157', Z-Tech	5758	11.2 x 24	11.9	12.1	12.6
		11.2 x 38	9.0	9.2	9.5
		14.9 x 24	9.0	9.2	9.5
		16.9 x 24	5.4	5.5	5.7
		Z-Trax	3.4	---	---
6-5/8" - 179', Z-Tech	6564	11.2 x 24	13.6	13.8	14.2
		11.2 x 38	10.2	10.4	10.7
		14.9 x 24	10.2	10.4	10.7
		16.9 x 24	6.2	6.3	6.5
		Z-Trax	3.8	---	---
5-9/16" - 135'	4,420	11.2 x 24	9.1	---	---
		11.2 x 38	6.9	---	---
		14.9 x 24	6.9	---	---
		16.9 x 24	4.1	---	---
5-9/16" - 157'	4,940	11.2 x 24	10.2	---	---
		11.2 x 38	7.7	---	---
		14.9 x 24	7.7	---	---
		16.9 x 24	4.6	---	---
5-9/16" - 160'	5,011	11.2 x 24	10.4	---	---
		11.2 x 38	7.8	---	---
		14.9 x 24	7.8	---	---
		16.9 x 24	4.7	---	---
5-9/16" - 179'	5,450	11.2 x 24	11.3	---	---
		11.2 x 38	8.5	---	---
		14.9 x 24	8.5	---	---
		16.9 x 24	5.1	---	---
5-9/16" - 201' (Water Drive)	5,710	11.2 x 24	11.85	---	---
		14.9 x 24	5.35	---	---
5-9/16" - 201'	6,135	11.2 x 24	12.7	---	---
		11.2 x 38	9.6	---	---
		14.9 x 24	9.6	---	---
		16.9 x 24	5.7	---	---

\* For Medium Clearance Towers add 103 lbs and for non-tow High Clearance towers add 322 lbs.

\*\* Contact areas and ground pressure based on manufacturers data at recommended load and inflation.  
(Based on 3" penetration)

\*\*\*Additional span weight based on 900 lbs. per span for two Z-Trax.

**NOTE:** Z-Trax only available on 6-5/8" and larger diameter pipe machines.

## Slope/Ridge Limitations

(Lateral/Transverse Slopes)

This table refers to the maximum percent slopes that are allowed by certain spans and towers. This chart combines the slope and ridge limitations and limits percentage on which the machine can transverse.

Span Size	*** 0-6" Ridge		***8" Ridge		***10" Ridge		***12" Ridge	
	*Solid Joint	**Swivel Joint	*Solid Joint	**Swivel Joint	*Solid Joint	**Swivel Joint	*Solid Joint	**Swivel Joint
10" - 113'	8%	NA	8%	NA	8%	NA	8%	NA
10" - 135'	8%	NA	8%	NA	8%	NA	8%	NA
8" - 113'	15%	30%	14%	29%	13%	28%	12%	27%
8" - 135'	15%	30%	14%	29%	13%	28%	12%	27%
8" - 157'	15%	NA	14%	NA	13%	NA	12%	NA
8" - 160'	15%	NA	14%	NA	13%	NA	12%	NA
8" - 168'	8%	NA	8%	NA	8%	NA	8%	NA
8" - 179'	8%	NA	8%	NA	8%	NA	8%	NA
8" - 186' 8"	8%	NA	8%	NA	8%	NA	8%	NA
6 5/8" - 113'	15%	30%	14%	29%	13%	28%	12%	27%
6 5/8" - 135'	15%	30%	14%	29%	13%	28%	12%	27%
6 5/8" - 157'	15%	NA	14%	NA	13%	NA	12%	NA
6 5/8" - 160'	15%	NA	14%	NA	13%	NA	12%	NA
6 5/8" - 168'	15%	NA	14%	NA	13%	NA	12%	NA
6 5/8" - 179'	15%	NA	14%	NA	13%	NA	12%	NA
6 5/8" - 186' 8"	12%	NA	11%	NA	10%	NA	9%	NA
6 5/8" - 201'	12%	NA	11%	NA	10%	NA	9%	NA
6 5/8" Z-Tech - 113'	15%	30%	14%	29%	13%	28%	12%	27%
6 5/8" Z-Tech - 135'	15%	30%	14%	29%	13%	28%	12%	27%
6 5/8" Z-Tech - 157'	15%	NA	14%	NA	13%	NA	12%	NA
6 5/8" Z-Tech - 179'	15%	NA	14%	NA	13%	NA	12%	NA
5 9/16" - 113'	15%	30%	14%	29%	13%	28%	12%	27%
5 9/16" - 135'	15%	30%	14%	29%	13%	28%	12%	27%
5 9/16" - 157'	15%	NA	14%	NA	13%	NA	12%	NA
5 9/16" - 160'	15%	NA	14%	NA	13%	NA	12%	NA
5 9/16" - 179'	15%	NA	14%	NA	13%	NA	12%	NA
5 9/16" - 201'	12%	NA	11%	NA	NA	NA	NA	NA

\* The solid joint column refers to both lateral and transverse slope.

\*\* The swivel joint column only refers to the transverse slope.

\*\*\* This heading refers to the ridges produced by cultivated row crops.

---

*Notes*



# Engineering Design Reference and Resource Guide

## **Bid Specifications Example**

Zimmatic Land Application Systems



## *Notes*

# ***Table of Contents***

## **BID SPECIFICATIONS EXAMPLE**

<b>Scope .....</b>	<b>6-5</b>
<b>General Description.....</b>	<b>6-5</b>
<b>Specifications.....</b>	<b>6-5</b>
Structural Design.....	6-5
Span Couplers and Joints .....	6-8
Wheel Gear Boxes for Self Propelled Towers.....	6-8
Drive Shafts and Aluminum Couplers .....	6-10
Center Drive Gear Boxes and Electrical Motors .....	6-10
Wheel Sets.....	6-11
General Electrical Specifications.....	6-12
FieldNET Telemetry Package .....	6-17
Nozzling .....	6-20

## *Notes*

---

## SCOPE

A quantity of one center pivot irrigation system to irrigate 800 GPM on 141 acres of bermuda grass. The nominal radius of the center pivot shall be 1300 feet. A big gun on the end of the system shall catch areas in the corners. The elevation at the center is 3475 feet. The highest point in the rotation of the center pivot is 3500 feet. The lowest point in the center pivot rotation is 3460 feet. The soil is primarily clay with a water intake rate of 0.3 inches per hour.

Unit Number	Total Length	Number of Spans	Span Lengths and Pipe O.D.	Overhang Length and Pipe O.D.
1	1297'	7	7-179' spans with 6-5/8" pipe	44' overhang with 5-9/16" pipe

## GENERAL DESCRIPTION

The center pivot irrigation system shall be electrically powered and controlled. The drive train shall have electric motors powered by 440 to 500 volts three-phase electricity. The electric motor and center drive shall provide power to the wheel gearboxes at each end of the drive tube. The wheel gearboxes will have pneumatic rubber tires. Three-phase electricity, 480 volts, shall also power the center pivot control panel. It shall be a computerized panel that allows for programing start and stop times. There will be an end of pivot light and a light at the pivot control panel to illuminate the panel. The system should be set up with a telemetry package to control the pivot from a personal computer on the internet. This program should be capable of keeping records of the amount of wastewater applied. Sprinklers shall be mounted on drops.

## SPECIFICATIONS

### STRUCTURAL DESIGN

1. Heavy Duty Pivot Point Structure.

The heavy duty pivot point structure will be constructed of four legs. Each leg shall be 4" x 4" x 3/8" angle iron and be 11' long. Each side shall have three horizontal ties with the angle iron having the dimensions of 2" x 2" x 3/16". The top tie on each side shall be 1-1/2" x 1-1/2" x 1/8" angle iron. Rolled formed angle iron is unacceptable. Non-tow anchor weldments are used on non-towed structures for the footings. The footings must be bolted to the outside of the pivot point legs and not to the inside of the legs. The base of the pivot point shall measure 10'-1-3/4" x 10'-1-3/4" on the outside of the pivot legs. Smaller dimensions will not be acceptable.

2. 8" Elbow, Head and Riser with a 6-5/8 Pivot Ell Joint

The 90° rotating elbow will be constructed of 8" O.D. cast iron and be welded on the upper side to a 6-5/8" O.D. (11 gauge) pivot ell joint. The pivot ell joint must be adaptable to the pipe diameter of the first span. The cast iron elbow will be welded on the lower side to a steel pivot ell pipe all galvanized. The steel pivot ell pipe shall

---

be 8" O.D., 11 gauge (0.107" wall) tubing with a length of 41-5/8". The pivot ell pipe will be inserted into a pivot head. The pivot head shall be 8-5/8" O.D. with a 0.219 wall thickness and it shall be 35-7/8" long. This pivot head shall have four pieces of angle iron welded at an angle of 33° from parallel to the pivot head. The angle iron shall be 31-1/4" long. A welded gusset shall brace each angle iron to the pivot head. The riser shall be constructed of galvanized 8" O.D., 11 gauge (0.107" wall) tubing. There shall be an 8" female coupler welded to the top of the riser. The riser and coupler shall be 75-3/4" long. There must be an 8" O.D. 90° steel elbow on the bottom of the riser.

The pivot point gasket shall be round, a triple lip seal and readily changeable.

There will be four 2" x 3/8" flat straps to stabilize the pivot riser.

3. The center pivot lateral pipeline size will be 6-5/8 inches O.D., with an 11 gauge (0.107 in. min. (2.72 mm) wall thickness (min.)) The overhang shall have a pipe of 5-9/16 inches O.D., with a 12 gauge (0.097 in. min. (2.46 mm)) wall thickness ( min.).

The center pivot lateral pipeline shall have ear brackets welded on each side of the pipe. The ear brackets are 3" x 3/16". The truce braces are connected to the ear brackets.

Flanges are welded to the end of each section of pipe. The flanges shall be pull tested to 15,000 lbs on the 6-5/8" O.D. pipe and 12,000 lbs on the 5-9/16" O.D. pipe after being welded. The flanges are produced from 3/8" thick steel material. Other types of flanges are unacceptable. The flanges have six holes to bolt together the sections of pipe.

4. The center pivot lateral pipeline shall use sprinkler outlets which are formed and tapered from the pipe material. The pipeline must be galvanized. The outlets shall be roll-threaded to form a tapered outlet. The thread profile must be tapered such that 3/4" NPT sprinklers and pipes will exactly seal against them. Sprinkler outlets must be exactly placed. The forming of the outlet is accomplished through robotically forming the outlet. Sprinkler outlets with welded couplers and straight threads will be unacceptable.
5. Towers shall be constructed of four legs, each with the dimensions of 4" x 3" x 1/4" and 11' long. Three horizontal ties shall be on one side of the tower structure. They shall be constructed of 1-1/2" x 1-1/2" x 1/8" angle iron. One stabilizer attachment will be on each side of the tower. These stabilizer attachments shall have a cross dimension of 3" x 3" x 3/16". Stabilizer angles shall be crossed and attached to the tower legs at the stabilizer attachments and to the bottom of the truss braces, not to the mainline pipe. The truss brace ends of the stabilizer angles shall be about 5' apart. They will be constructed of 3" x 3" x 3/16" angle iron that is 19' 4-1/2" long.
6. The drive tube shall be 6-5/8", 11 gauge tubing and 13' 8" long. Tower leg mounting plates shall be welded to the drive tube frame in an "A" type frame. This "A" frame shall consist of a tower leg mount and a leg mount brace. The tower leg

---

mount and leg mount brace shall be formed from steel with a 1/4" thickness. The tower legs are bolted to the "A" type frame.

7. Truss rods shall be a fixed length of 22' with large hot headed ends. They will be 1 1/16" diameter or 3/4" and will not be adjustable. Only one length of truss rods are allowed on the standard span lengths. This is to insure uniform loading and an uniform arch in each span. The truss rods should be anchored to 3/8" rod anchors, not through the pipe flanges. The rod anchors use a safety factor of 2.5.
8. Truss braces shall be in a "V-jack" design. There shall be a truss brace pair on each side of the pipeline. The truss braces shall connect to the ear brackets on the pivot lateral pipeline. A truss tie shall connect the bottom of each truss brace pair on each side of the pipe. An angle truss plate is bolted between two truss braces on each side of the pipeline. It is bolted directly underneath the center pivot lateral pipeline to the truss braces. Each set of four truss braces and cross ties shall be spaced 22 feet apart on standard span lengths. The truss braces shall be the dimensions of 2" x 2" x 3/16" and 2" x 2" x 1/8". Truss ties shall be the dimensions of 1-1/2" x 1-1/2" x 1/8" and the third tie shall be the dimensions of 2" x 2" x 1/8". The angle truss plates shall be 1/8" thick.
9. Clearance between truss rods and ground shall be no less than 9'-0".
10. Upon fabrication, all structural steel members, such as the span pipe, angle iron, small trussing parts, central pivot members and self propelled tower members, shall be hot-dipped galvanized to ASTM 123-73 specifications. A heavy coat of galvanization of not less than 3.5 mils (0.0035") average shall be applied. Painting and other types of applied coatings will not be acceptable on these members.
11. All bolts shall be grade 5 or better. All structural assemblies shall use locknuts on the bolts. The locknuts and bolts shall be zinc plated.
12. A factor of safety of 1.5 applied to yield strength shall be used in all structural calculations except:
  - a. The system shall be designed to withstand wind loads at velocities of 90 m.p.h. and a 1.1 safety factor. The wind load calculation shall be made without water in the system and with the system located on flat ground.
13. The pivot structure and all other structural members shall be designed to applicable AISC specifications.
14. All welding shall be done in accordance with best welding practices as outlined by the American Welding Society (AWS). Welding shall be done by qualifie welders.

---

## **SPAN COUPLERS AND JOINTS**

1. The coupler construction shall be an external split aluminum coupler comprised of two halves bolted together with a flexible one-piece rubber inner boot having a compression V-lip seal at each end to provide sealing. The gaskets shall seal tight when operating water pressure is applied. The coupler shall be free to flex and shall carry no structural loading. The design shall be such that the inner boot can be changed readily without requiring heavy lifting equipment or extensive dismantling of the span. Exposed rubber boots with tee-clamps will not be acceptable at the tower joints.
2. All joints shall be constructed like a large universal joint for allowing movement of the spans. There shall be four points of attachment on a ring. Attachment will be made with 3/4"-10 x 2" Gr. 5 bolts and 3/4" lock nuts. This joint will distribute motion uniformly. These joints are capable of traveling on lateral or transverse slopes up to 15%. Ball and socket joints or internal hook and eye type will not be used.

There shall be no internal obstructions causing turbulence or flow reduction within any sections of the pivot pipe.

3. Each joint shall be equipped with an automatic drain in the lowest point of the span. These drains close when under pressure and open when the pressure is relieved. The appropriate drain material shall be selected based upon system operating pressure.

## **WHEEL GEAR BOXES FOR SELF PROPELLED TOWERS**

1. The wheel gearbox is located at each wheel and is constructed of a bull gear and worm gear shaft. It shall develop torque adequate to propel the system up to 30% slopes. The wheel gearbox drive shall be capable of delivering at least 120,000 in-lbs of instantaneous torque and at least 60,000 inch-pounds of CONTINUOUS torque. The gearbox shall deliver vertical loads of 7000 pounds CONTINUOUS and 9000 pounds intermittent load. The wheel gearbox drive shall have an output ratio of 50:1.
2. Mechanical specifications of the wheel gearboxes shall include, but will not be limited to, the following considerations:
  - a. Gear cases will be designed specifically for center pivot systems.
  - b. The wheel gearbox shall have two double lip seals on the worm gear shaft and triple lip seals on the output shaft.
  - c. Wheel gearboxes shall be filled with 85140-GL5 oil to the normal operating level, which shall submerge all bearings. Wheel gearbox oil quality will meet MIL-2105B specifications. Replacement of oil and oil specifications must be met as noted in the Center Pivot Operation Manuals.

- 
- d. The wheel gearboxes will be hermetically sealed. An expansion chamber will be incorporated to maintain minimal changes in internal pressure due to temperature changes (up to 150°F), and providing total isolation from water vapor transfer into the gear case. Internal expansion chamber volume shall be at least 30.0 in<sup>2</sup>. A smaller volume of internal expansion chambers will be unacceptable.
  - e. The bull gear is manufactured from gray iron with a Brinell hardness of 240. The bull gear has an outside diameter of 9" and an inside diameter of 2 1/4". The face width is 2" while the web thickness is 1".
  - f. The worm gear shaft consists of high tensile 1045 material with a Brinell hardness of 210. It has a dual 1" input shaft, a 2-3/8" diameter worm gear and a bearing spread of 6".
  - g. The bull gear and worm gear shaft pressure angle have been designed at 14.5°.
  - h. The wheel gearbox shall have high strength iron worm gear shaft end caps with steel inserts held by 4 bolts. Each end cap shall have a water ledge to deflect water off the case away from the seal area.
  - i. The bull gear and worm gear shaft will use a four tooth engagement in its gear tooth mesh.
  - j. Wheel gearbox shaft stress, including the output shaft, shall conform to AGMA Standard #260.01.

The output shaft shall be 2-1/4" in diameter to assure suitable rigidity to maintain gear alignment. This dimension is continues from the wheel shaft bearing and inward to the wheel gearbox.

The output shaft shall be no longer than 1-1/2" between the bearing and the wheel mounting face to minimize weight loads on the shaft.

The wheel mounting face shall have a 6" pilot for wheel support. The pilot is a flange for wheel support. There must be eight 1" diameter lug nuts to bolt the wheel to the wheel mounting face. The face shall be 9" in diameter. The non-pilot thickness shall be 1/2". With the pilot, the thickness of the face will be 28/32". Wheel mounting faces without the pilot face or with lug nuts smaller than 1" in diameter will be unacceptable.

- k. The wheel gearbox will use five 1/2" bolts to attach the gearbox to the gearbox mounting plate welded to the drive tube. The bolt holes are in a circle pattern.

- 
- I. Each wheel gearbox reduction mesh will be capable of passing the following 500 hour unidirectional qualification test without scoring, pitting or breaking.
    - Random loading.
    - Minimum output torque - 10,000 in-lbs
    - The output torque shall vary between 18,000 and 55,000 in.-lb. and will be applied for no less than 10% of the time.
    - The load shall be at least 24,000 in-lbs for at least 25% of the time.
    - Power will be interrupted each minute (approximately) and the mesh allowed to remain static for one minute (approximately) to provide a "start-stop" cycle.
  3. The design and rating of all wheel gearbox meshes will be of substantial agreement with the norm established in AGMA Standard #440.03. The bull gear and worm gear shaft shall achieve proper fit at the beginning of operations.

### **DRIVE SHAFTS AND ALUMINUM COUPLERS**

1. Drive shafts shall be 7/8" square. They shall be able to deliver a maximum torque to the wheel gearboxes. Minimum deflection of the drive shaft shall not exceed 1/360 of the span length.
2. Aluminum drive shaft couplers will be used at the end of each drive shaft. Aluminum couplings used to join the center drives, drive shafts and wheel gear boxes and will be designed to facilitate removal.

### **CENTER DRIVE GEAR BOXES AND ELECTRICAL MOTORS**

1. Each tower shall be propelled by a center drive gearbox and an electrical motor approximately located at the center of each drive tube.
2. Mechanical specifications of the center drive gearboxes shall include, but will not be limited to, the following considerations:
  - a. Gear cases will be designed specifically for center pivot systems.
  - b. Center drive output rotating shaft sealing shall include four single lip, 2 seals per side, spring loaded oil seals.
  - c. Center drive gearboxes shall be filled with 20W-GL4 oil to the normal operating level, which shall submerge all bearings. Replacement of oil and oil specifications must be met as noted in the Center Pivot Operation Manuals.
  - d. The center drive gearbox shall be a triple gear reduction and of the spur gear type. The gears shall provide an output ratio of 40:1 for the electrical motor. No helical gears are used.

The gears shall be made from powdered metal and not heat treated or machined.

- 
- e. The center drive gearbox shall be capable of 7200 in-lbs output torque. It shall be 95% efficient.
3. The electric motor's design shall comply with applicable provisions of NEMA and IEEE standards.
  4. The electric motor will be designed specifically for center pivot applications including the special considerations of keeping moisture out. The electric motors shall be provided with a metal shroud which protects it from rainfall and spray applications. In addition, the shroud shall provide for movement of cooling air over the surface of the electric motor. The shroud will be covered by a plastic motor cover for additional water protection.

The electric motors shall be rated for a continuous duty cycle and have inherent overload protection.

The winding insulation shall be double varnish dipped and baked, and shall be NEMA Class "B" or better.

Ball bearings shall be double sealed.

5. The centerdrive motors for the center pivot shall consist of the following:

**3/4 HP, 43 RPM**

- 1.5 amp (full load) at 480V and 1.43 amps (full load) at 380V
- a 3/4 HP TENV
- 40:1 ratio
- 43 RPM output at 60 HZ and a 33 RPM output at 50 HZ
- 3 phase
- a 1000 in-lbs torque (full load).

## **WHEEL SETS**

1. Each self-propelled tower shall be provided with two rubber tires. All tires provided shall be of the same manufacturer and model. These will be of an agricultural load tractor type with a suitable lug design (R-1) and an adequate load rating.
2. The tires shall be 14.9 x 24 tires with 8" or larger rims. The tires shall have a tread width of 14.5", a diameter of 49.8", a circumference of 179.0" and a contact area of 346 in<sup>2</sup>.

---

## GENERAL ELECTRICAL SPECIFICATIONS

1. Electrical service to center pivot equipment should meet the American Society of Agricultural Engineers (ASAE) Standard S397.2 "Electrical Services and Equipment for Irrigation." This standard is approved by the Irrigation Association.  
The center pivot shall meet the American Society of Agricultural Engineers (ASAE) Standard S362.2 "Wiring and Equipment for Electrically Driven or Controlled Irrigation Machines."
2. The following sections of the National Electric Code (NEC) apply to electric drive center pivot irrigation systems, and shall be adhered to accordingly.
  - a. Article 250-51 Effective grounding.  
Article 250-114 Effective grounding.
  - b. Article 310 Minimum size of conductors.
  - c. Article 210-5 Color code for branch circuits.
  - d. Article 430 Motors, motor circuits or controlled.
  - e. Article 675 Irrigation machines.
3. All control panels shall be readily accessible to the maintenance personnel. They shall be totally weatherproofed. Entrances into, exits from and penetrations of the enclosure shall be made in such a manner as to reduce the possibility of collection of water or contaminants at the point of connection and shall also be made in such a manner as to preserve the minimum NEMA 3R rating of the enclosures. NEMA 3R states that the control panel enclosure is outdoor and weather resistant. Dimensions of enclosures shall not be less than the maximum dimensions of the enclosed equipment plus the required electrical clearances as specified in the National Fire Protection Standard No. 70, National Electrical Code. Enclosures shall be made of corrosion resistant materials and shall have doors covering the controls to prevent damage. Doors will have non-corroding hinges or other means of attachment. Locking mechanisms shall also be provided on the master control panel and the main disconnect.

- 
4. The Master Control Panel for each pivot shall be mounted to the pivot point.

**FieldVision Panel - Programmable**

The panel shall include the following controls and features.

- a. The FieldVision control panel for each pivot shall be mounted to the pivot point.
- b. The FieldVision control panel shall include the following controls and features.
  - System power controls
  - Forward and reverse directional controls
  - Digital percent timer to enter inches or percent rates
  - Absolute position monitor and controls of field location (0-359 degrees)
  - Auto-restart
  - Programmable auto-shutdown and auto-reverse controls
  - Two (2) auxiliary controls
  - Nine (9) automated user-defined irrigation programs with up to twenty (20) steps each
  - Four (4) programmable endgun tables with up to eight (8) steps each
  - 50 step history log showing date, time, location and pivot events
  - Timers for run-time, endgun, pivot, pump, auxiliary 1 and auxiliary 2
  - Programmable service stop
  - Monitor pressure with optional sensors
  - Pump protecting delays and timer limits
  - Deviation of speed based on temperature or time
  - Low pressure shutdown and restart
  - Low voltage shutdown and restart
  - Pump load management
  - User-friendly menus and prompts
  - Easy on-line diagnostics on the run-time screen
  - Rainfall shutdown (with optional sensor)
  - High wind shutdown (with optional sensor)
  - High flow and low flow warnings (with optional sensor)
  - FieldNet and Telemetry compatible
- c. A nameplate shall state the manufacturer's name, the design voltage, phase, frequency of the incoming power supply and the amperage per phase, which shall be the ampacity of the recommended over current protection for the main power circuit.
- d. Transformers shall be capable of handling voltage reductions required for all functions of the control system. Transformers shall be of the isolation type with proper over current protection for the transformers, conductors or control device they serve. All control circuits shall operate at 120 VAC. except for the remote pump kill, which operates at 24 VAC.
- e. The panel classification shall be NEMA 3R - rain proof - sleet resistant - outdoor type.

- 
- f. There must be a main disconnect in the panel to shut off the flow of power through it.
  - g. A four (4) line by 40 character LCD screen shall present information on the following:
    - Day of week
    - Date (month and day)
    - Time (hour:minute:second am/pm)
    - Manual mode or program mode (program number and next step to run)
    - Pivot Pressure
    - Temperature
    - Voltage
    - Absolute Field position (0-359°)
    - Full Circle Time (at current application rate)
    - Service stop setting
    - Auto Reverse Status (on/off)
    - Auto Restart Status (on/off)
    - Pivot status
    - Rotation Status
    - Depth Applied or Percent Setting
  - h. The LCD screen should also provide the following statuses:
    - Countdown of pump timers (restart delay, pressure-up delay and pump recovery)
    - Hours of operation for: pivot, pump, endgun, auxiliary 1 and auxiliary 2
    - With optional flow meter: water flow rate, two (2) totalizers (one non-re-settable and one re-settable)
    - With optional rain sensor: total rainfall, period rainfall, shutdown value and shutdown period, where total and period rainfall is re-settable and logs the date reset
    - With optional wind sensor: wind heading, wind speed, recorded high, wind speed shutdown and delay time
  - i. System operating information must also be shown via LED's next to the applicable function keys for the following information:
    - Rotation status(reverse, off or forward)
    - Status of auxiliary equipment
    - Wet or dry mode
    - Endgun status
  - j. It must have the ability to operate the system either manually or via a preset program.
  - k. There will be a Wet-Dry operations key to permit operation of the pivot during periods when no spraying is required.
  - l. Speed of the last tower shall be controlled by either percent setting or depth of application.

- 
- m. There shall be a recording device to accumulate the total number of hours of operating time of the pivot, pump, end gun and (2) auxiliaries.
  - n. An Automatic Restart feature shall be available to restart the pivot after a momentary power interruption and after power is restored.
  - o. There will be a Low Temperature shutdown feature to prevent the pivot from operating below a preset temperature.
  - p. There will need to be the following features:
    - An End Tower light must be available, which readily allows the operator to see from a distance when the center drive motor for the last tower is on or off.
    - A Main Panel Light must be available to illuminate the Master Control Panel and facilitate operation of the system at night.
  - q. The panel must have the ability to be programmed based upon its position in the field. The degrees of rotation of the system are to be determined by an absolute position encoder mounted near the top of the pivot riser.
  - r. The panel will be used with a Telemetry package.
5. A main disconnect switch is to be provided with over current protection and capable of being locked in the OFF position. It is located at the point of connection of electric power to the machine. The switch shall be rated at 30 amps and 600 volts minimum. A suitable lightning arrestor shall be provided.
6. Tower alignment control shall use microswitches and motor contactors actuated through a mechanical linkage from a uniknuckle joint. The tower alignment mechanism shall be electrical and mechanical operated. The mechanical linkage shall be a threaded stainless steel alignment rod. One end of the threaded rod shall have a metal ball and socket joint bolted to a cam arm. The cam arm is bolted to a cam that it turns, which then actuates two microswitches. One microswitch shall control the "on" and "off" intervals of the center drive motors. A second switch shall act as a safety shut down of the center pivot to the pivot control panel if misalignment occurs. The other end of the alignment rod shall also have a metal ball and socket joint that is bolted to an arm welded to the uniknuckle joint. This end of the alignment rod must adjustable.
- There shall be a spring connected to the cam to provide resistance to the cam arm. It shall be 0.047 hard drawn wire with a 0.375 O.D. Its length at rest shall be 2-3/4". It shall be zinc plated.
- The cam and cam arm are constructed of special acetal-delrin 500 materials. There shall be no steel cam assemblies or nylon bushings.
- The alignment mechanism will not be affected by changes in the terrain for slopes up to 30%. The alignment system shall be capable of operating when the machine is reversed without the necessity of making adjustments.

- 
7. Machine safety shall shut the system off if normal alignment is not maintained. There shall be safety interlocks. One such device is an electrically actuated misalignment mechanism to render the system inoperative if misalignment of the system occurs. The water supply is also shut off during the time the system is rendered inoperative. An overwatering safety device will render the pivot inoperative if the end tower stops for more than a pre-set number of minutes. A controlling timer shall be of the variable type with time settings between zero and five minutes, and will adjust per main panel percentage rate.
  8. Each tower shall have a tower box to control its functions. The tower box is UL/C.S.A. listed - Industrial Control Panel. The box shall include:
    - a. A definite purpose extended life contactor rated at 25 amps, 600 volts, 10 h.p., and for 1 million mechanical operations.
    - b. Microswitches rated 277 volts at 15 amps, 1/4 h.p. and tested to 10 million cycles. They shall be constructed of a snap spring, type 301 stainless steel, with a copper inlay strip and with silver contacts.
    - c. On-off switch rated at 10 amps and 600 volts.Each tower box shall be fitted with a suitable weather-tight enclosure. This enclosure shall be constructed of a polycarbonate base and polypropylene cover. The cover must have a positive seal against the base and it must be corrosion resistant. No steel enclosures or bases will be used. Neither shall any foam seals be used to seal the cover to the base.
  9. All systems shall have proper grounding. The grounding conductor must be supplied with the electrical service to serve as an interconnection between the power source ground and all non-current carrying metal parts of the installation. This would include the disconnect switches, pump panels, conduit, junction boxes, pump motors and the center pivot. This conductor must be sized properly to carry any fault current that could develop. The center pivot and master control panel shall be connected to a driven grounding electrode in accordance with the latest edition of the National Electrical Code (section 250).
  10. Safety signs describing the automatic starting of the machine, grounding requirements, high voltage, caution and other pertinent safety signs shall be provided and prominently displayed.
  11. An external collector ring shall be used on the 5-9/16", 6-5/8" and 8" pivot point structure. The external collector ring shall have a minimum of 10 rings rated at 30 amps and 600 volts. Dual spring loaded brushes on the rings shall have an area of 0.25 in<sup>2</sup>. External collector ring enclosures shall be weather tight to eliminate the possibility of ingress of moisture or contaminants at the points of connection. The shield is constructed of fiberglass. The electric cable connecting the main panel to the collector ring shall be outside any water carrying member. A

---

power cable going through the inside of riser is unacceptable.

12. The position encoder shall be located in a water tight enclosure. The enclosure shall be constructed of the same material that the tower box is constructed. This enclosure shall be bolted to the pivot head. An 8" pin ring shall be bolted to the pivot ell pipe. The position encoder shall have a shaft attached to it. The shaft shall be attached to an 8" encoder gear. The encoder gear shall have grooves along the edges that the pins of the 8" pin ring rest.

The position encoder shall be an absolute position monitor and know where exactly the rotation of the pivot is at from 0 to 359°. As the pivot ell rotates the 8" pin ring, it shall turn the 8" gear plate. This plate will thus turn the absolute position encoder.

13. Conductors in the irrigation cable shall be at least #14 gauge copper type THWN stranded for all control circuits, at least #18 gauge copper type THWN stranded for low current signal carrying circuits and at least #14 gauge copper type THWN stranded for all three phase motor power conductors. Conductors used to connect or interconnect to or between components within an enclosure shall be rated not less than 600 vac. for circuitry utilizing 300 volts or less and not over 600 vac. Cable jacketing shall be resistant to sunlight, moisture and corrosion as per NEC 675-4. It should also provide mechanical protection, flexibility and be suitable for operation within a temperature range of -40°F to 140°F. All conductors shall be color coded for proper identification and this coding shall be uniform throughout the entire system.
14. There shall be a booster pump for the endgun. The 130 GPM pump shall operate at 4 amps (full load) at 460V. Additionally, it shall operate at a maximum of 130 GPM and a minimum of 65 GPM. At 60 HZ the booster pump motor shall run at 3450 RPM.

## **FIELDNET TELEMETRY PACKAGE**

1. Telemetry features and capabilities include the following:
  - a. It shall have Radio Telemetry that connects to a COMM port on the personal computer (PC) and provides remote access to the master control panel. This access allows the user to do everything from the PC that could be done at the key pad of the FieldBOSS control panel.
  - b. It shall have the ability to automatically compile information to aid record keeping and reporting.
  - c. It shall have a summary screen that displays information on each pivot including hours of operation, water use, pumping cost and environmental data.
  - d. Each FieldVision control panel shall have special telemetry software (EPROM) that enables the pivot events to be relayed to the Base Station in real time without the need to poll for status.

- 
- e. The Base Station software shall include drawing tools to draw circles or part circles, polylines, polygons, rectangles, squares, circle ellipses and text.
  - f. The Base Station software shall include drawing properties to allow the drawing of non-pivot shapes such as the solid choice of colors and/or patterns.
  - g. The Base Station software shall include two views for displaying the pivots. One view is a map view showing the colored circles. The second view is a table view that represents information in a spreadsheet.
  - h. The Base Station software shall display the pivots on the map with different colors representing unique statuses. The colors shall be coded like the following:
    - Blue = Running wet
    - Orange = Running wet with one or more auxiliaries on
    - Green = Running dry
    - Gray = Pivot is off
    - Yellow = Running in a warning or timer countdown
    - Red = Shutdown
  - i. The Base Station software shall display the location and direction of travel of the pivots on the map with a solid black line and arrow, which is part of the pivot circle. A service stop location shall be displayed with a dashed line.
  - j. The Base Station software shall have the capability to monitor more than one map site at a time
  - k. The Base Station software shall be compatible with Microsoft's Access database program for Windows 95 or higher.
  - l. The Base Station software shall interface with the call-out alarm so whenever a circle turns red or yellow, the call-out alarm will call up to two (2) phone numbers to announce the shutdown or warning.
  - m. The Base Station software shall have the capability to select which alarm conditions will or will not be called out.
  - n. The call-out alarm shall connect to a COMM port on the PC and a phone line.
2. Requirements at the Pivot include the following:
- a. There shall be a Telemetry panel located at the pivot point and connected to the FieldVision control panel.
  - b. Communication (Radio, Phone or Direction Connection)
    - The telemetry panel shall be equipped with a 12 VDC power supply, packet modem using AX2512V2 protocol, data radio programmed between 450-470 MHz UHF and an UHF antenna.

- 
- The panel shall be equipped with a Hayes compatible phone modem to use with either, landline or cellular phone and a cellular connection (Motorola S1936D).
  - The panel must be equipped with a RS-232 to RS-485 converter for direct connection to the personal computer (PC).

**Note:** There is a limited number of pivots and a limited distance applicable with this method.

3. Requirements at the Base Station include the following:

- a. The Telemetry software shall run under Windows 95 or higher and on an IBM compatible personal computer (PC) with the following minimum hardware specifications (customer supplied):
  - Pentium 90 MHz processor or higher
  - 16 MB RAM or higher
  - 20 MB of free hard drive disk space
  - CD ROM for loading software
  - Two (2) free COM ports required, three (3) recommended
  - Recommend a bus mouse over a serial mouse
  - SVGA monitor recommended
  - Carbon Copy or PC Anywhere software recommended to remote control and support
- b. Communication (Radio, Phone or Direct Connection)
  - The Base Station shall be equipped with Windows-based Telemetry software, 12 VDC power supply, packet modem using AX2512V2 protocol, data radio programmed between 450-470 MHz UHF and an UHF antenna
  - The Base Station shall be equipped with a Hayes compatible phone modem to use with either, landline or cellular phone and a cellular connection (Motorola S1936D).
  - The Base Station must be equipped with a RS-232 to RS-485 converter for direct connection to the personal computer (PC).

**Note:** There is a limited number of pivots and a limited distance applicable with this method.
- c. The base station shall be equipped with a phone call-out alarm and a dedicated phone line. This alarm shall call up to, two (2) phone numbers for each pivot. This alarm shall provide a voice identification of announcing the word "telemetry" so the person that answers the phone knows what is calling. Once the person acknowledges by pressing the star key (\*) on the phone, the alarm will then announce the pivot name and specific reason for shutdown. These reasons can include the following:
  - Safety shutdown
  - Low temperature shutdown
  - Low pressure shutdown
  - Low pressure warning
  - Load management shutdown
  - Low voltage shutdown

- 
- High voltage shutdown
  - Service stop shutdown
  - Power company shutdown
  - Low flow warning
  - High flow warning
  - Wind speed shutdown
  - Rainfall shutdown

## **NOZZLING**

1. The sprinklers should be placed on flexible hose drops that are 8 feet from the ground. The distal pressure at the end of the system should be 35 psi. A sprinkler with a wide radius of throw should be used. This will keep the average application rate low. The sprinklers should be regulated to provide even application of water across the field. The sprinklers need to provide some evaporation and mixing of air to allow decrease in odors.
2. A large volume gun on the end of the system should be able to add approximately 100 feet to the length of the center pivot radius.



# Engineering Design Reference and Resource Guide

## Economic Comparisons

Zimmatic Land Application Systems



## *Notes*



# Engineering Design Reference and Resource Guide

## Case Histories

Zimmatic Land Application Systems



## *Notes*