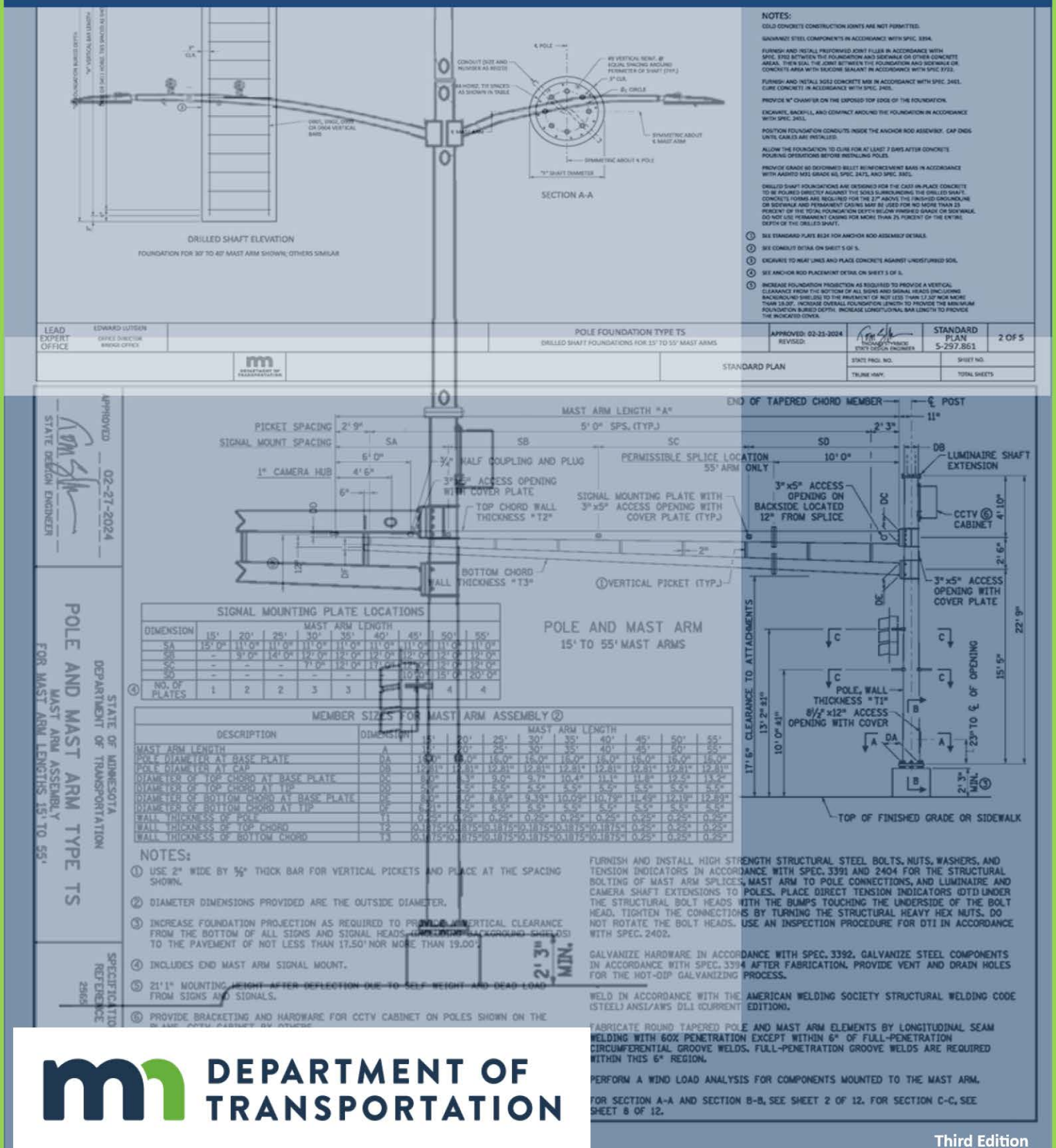
TRAFFIC SIGNAL (TS) POLE SYSTEMS
An Informational Guide for Signal Systems Using the New MnDOT TS Pole



DEPARTMENT OF TRANSPORTATION

Third Edition

Note: "TS" stands for Traffic Signal. In this publication the terms "TS Pole" and "Post and Mast Arm Type TS" are used interchangeably as well as "TS Pole Foundation" and "Pole Foundation Type TS".

Foreword

MnDOT is now designing signal systems using the new TS Pole for the 2025 construction season and beyond. With that comes change in how "we"- MnDOT, consultants, and contractors collectively have been designing, constructing, and inspecting signal systems for decades. The change is not only the introduction of the new Post and Mast Arm Type TS structure itself, but also related signal items that make up the "TS Pole system". This includes:

- Foundations
- Equipment Grounding
- Lightning Protection
- Pole Extensions and Camera and Luminaire Attachments
- Structural Bolting
- Anchor Rod Tightening

The purpose of this publication is to disseminate new information about the TS Pole systems into a single source informational guide for inspectors and contractors involved in signal system construction. For general signal system guidance and information refer to the Signals and Lighting Field Guide.

The objective of this publication is to help contractors and inspectors alike become familiar with the construction methods and requirements for the new TS pole signal systems. This ensures uniform installation of TS pole systems on MnDOT highways across the state.

The material presented is based on contract documents, but some content has been paraphrased. The information provided is subject to change as improved designs, materials, equipment, special applications evolve. Variation in standard requirements will more than likely develop after this informational guide has been published. Like the Field Guide, this publication cannot serve as a substitution for the construction project's actual contract documents.

Notice

This informational guide is published to serve as material for MnDOT Signals and Lighting Certification and Recertification class and E-learning trainings, and in the interest of information exchange for MnDOT signal construction projects. It is not a substitute for actual standards, specifications, or other contract documents.

Feedback

A certain amount of the content presented in this publication, although not new to many within MnDOT and DOTs across the country, is new explicitly to MnDOT's signal inspectors and contractors. Some of the information in this guide has never been tried and tested specifically on MnDOT signal projects. MnDOT Office of Traffic Engineering understands installation methods for TS Pole systems will be constantly evolving in years to come due to the lessons learned and real experience gained on the construction projects by contractors and inspectors.

Therefore, MnDOT Office of Traffic Engineering (OTE) Signals Unit encourages its "stakeholders"- district traffic offices, contractors, consultants, government agencies, and manufacturers to provide feedback regarding the

design and construction of TS Pole systems or this information guide. Working together we can improve the construction processes and procedures and design of TS Pole systems.

Your valuable feedback, positive or negative, is welcomed. Please provide your input to:

Sue Zarling
State Signal and Lighting Engineer
MnDOT Office of Traffic Engineering
651-234-7052
susan.zarling@state.mn.us

Alex Govrik
Electrical Systems Specialist
MnDOT Office of Traffic Engineering
612-523-9413
alex.n.govrik@state.mn.us

Table of Contents

CHAPTER 1 INTRODUCTION

1.1 Interchangeable Terms, Phrases, and Symbols

The following terms, phrases, and symbols listed are one in the same in this publication:

- "TS Pole" and "Post and Mast Arm Type TS"
- "TS Pole Foundation" and "Pole Foundations Type TS"
- "Standard Plan 861" and "Standard Plan 5-297.861"
- "15' to 55'", "60' to 80'", "15-55", "60-80", indicates mast arms and references arm lengths in feet (e.g., TS 15-55 means TS Post and Mast Arm Type TS for Mast Arm Lengths 15' to 55'. TS 60-80 means TS Post and Mast Arm Type TS for Mast Arm Lengths 60' to 80')

- Some of the text description and images for poles and foundations use "(single quotation mark) to indicate inches and '(apostrophe mark) to indicate feet (e.g., 5' 6" for 5 feet 6 inches)

1.2 Acronyms & Definitions

AASHTO	American Association of State Highway and Transportation Officials- A standards setting body of highway and transportation officials that establishes transportation standards and policies used in highway design and construction throughout the United States for uniformity on U.S. highways. The FHWA and state DOTs generally adopt those standards and policies set by AASHTO.
ASD	Allowable Stress Design- One of the earliest design methodologies used in structural engineering that involves calculating the applied loads on a structure and then analyzing the stresses developed within the members, but it does not explicitly include fatigue in the calculations.
CFR	Code of Federal Regulations- A compilation of the rules and regulations that are permanent and general for the executive departments and agencies of the United States federal government.
DOTs	Departments of Transportation- Typically referring to state government agencies that manage transportation within a jurisdiction.
FHWA	Federal Highway Administration- An agency within the U.S. Department of Transportation that supports state and local governments in the design, construction, and maintenance of the nation's highway system.
LRFD	Load and Resistance Factor Design- A more modern design methodology than ASD used in structural engineering. LRFD is considered a more comprehensive and accurate approach than ASD because it explicitly considers fatigue and the probability of failure.
NEC	National Electrical Code- A set of standards that outlines the safe installation of electrical wiring and equipment in the United States. It is considered the primary standard for electrical safety in the country and is often adopted by local jurisdictions as law.
NFPA	National Fire Protection Association- Is a private trade association that develops codes and standards for fire safety. NFPA publishes a comprehensive set of fire safety regulations (National Fire Codes). The NEC is one of these codes and is also published under the name NFPA 70.

WSD Working Stress Design- Same design method and concept as ASD. Both terms are used interchangeably.

1.3 Context and History

The FHWA requires DOTs to choose one of the following specifications when designing, fabricating, an erecting traffic signal structures:

- Revised AASHTO specification entitled Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 6th Edition, and includes 2013 and 2015 Interim Revisions.

Or

- AASHTO's LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 1st Edition, and all Interim Revisions.

The LRFD specification is a more comprehensive, improved specification that reflects the latest research and knowledge and, in the future, the FHWA will be phasing out the Standard Specifications, however no timeline for this transition has been established. Therefore, MnDOT has moved forward in the implementation of AASHTO's LRFD code for traffic signal structures. It is worth noting, and should be emphasized that regardless of either specification, LRFD or Standard Specifications, the outcome of the new TS Pole structures would have been the same. This is primarily because of the fatigue requirements included in both the LRFD and Standard Specifications.

The following section includes commonly asked questions with answers about the new Pole and Mast Arms Type TS and Pole Foundations Type TS to provide context and historical background.

1.4 Questions and Answers

Question: Why does MnDOT have to follow the AASHTO LRFD code for its Traffic Signal Poles?

Answer:

Like the NFPA 70 NEC Handbook provides a national code of standards for the electrical construction industry, so does the AASHTO LRFD or Standard Specifications code for DOTs engineering and designing structures for traffic signals. The obvious differences are, one is for electrical versus the other two are for structural design, and the NEC Handbook is not intended to be a design specification whereas the AASHTO LRFD and Standard Specifications are. However, there are similarities in that they provide a national code of standards to be applied in their respective fields for the primary goal of ensuring a level of uniform safety to protect persons and property from hazards.

Would it be fair and ethical to ask an electrician to provide electrical installation that follows an outdated edition of the NEC Handbook or alternative electrical guidance other than the current edition of the NFPA 70 NEC Handbook? Of course not! Licensed electricians are obligated to provide electrical installation in accordance with the current edition of the NFPA 70 NEC Handbook. Not following the NEC Handbook would be a violation of professional ethics and could lead to legal repercussions as it could potentially compromise safety.

The same holds true for MnDOT bound to follow the AASHTO LRFD or Standard Specifications code and the MnDOT engineers who are asked to sign off on structural standard plates and plans verifying the structure meets the most current editions of the AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals or the AASHTO Standard Specifications Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

Question: Why couldn't MnDOT continue to use the PA Pole and Mast Arm?

Answer:

For decades the PA Pole and Mast Arm structure has performed well for MnDOT. Designers, contractors, and MnDOT ESS have grown fond of the PA Pole and Mast Arm and MnDOT is disappointed to discontinue using the PA series pole. Making the decision to change was difficult but MnDOT discovered during the review process for a new structure that other states have also updated their design standards using the AASHTO LRFD code.

The PA Pole and Mast Arm structure originated in 1968 with release of Standard Plate No. 8123. Design requirements for the original components are unknown but are likely based on the governing design specification utilizing an ASD, also known as WSD. ASD does not directly account for fatigue in design calculations unlike the more advanced design method of LRFD and the Revised AASHTO Standard Specifications that do include fatigue. Fatigue, is when wind loading produces fluctuating stresses in structures, called cyclical loading, that can damage the structure over time, leading to cracks and potential failure.

When the structural design of the PA Pole and Mast Arm was analyzed against the LRFD criteria method, it was determined that the structure did not meet the required safety and strength standards set by this design method. Specifically, the design of the popular transformer base, so it was abandoned as it was not compatible with fatigue design of the LRFD. Additionally, other connection details between the PA mast arm and pole sections, and pole and baseplate required updating. For those reasons, MnDOT brought forward a new traffic signal pole structure to meet the required standards for structures in accordance with the AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

Question: The PA Pole and Mast Arm has been around for decades and proven to perform well. Why change?

Answer:

Most of us tend to judge the strength of structures based on appearance as time passes and being intact after weather events it was faced with. Despite the appearance of strength over time, older structural designs like the PA Pole and Mast Arm must be tested and reviewed against the new design standards of today, because of advancements in technology, a better understanding of material behavior, and changing environmental conditions like more extreme weather events. This is done for ensuring both the safety and reliability of MnDOT traffic signal poles.

MnDOT could not continue to use the PA Pole and Mast Arm knowing it does not meet the AASHTO LRFD code requirements. Especially the transformer base. Consider it from this perspective. There are existing electrical systems installed over 60 years ago that have continued to operate without any problems today. Fuse boxes are a case in point: even though modern homes today use breaker panels there are many existing older homes that have electrical systems still operating from fuse boxes. Does that mean the electrical industry should continue to allow installing electrical systems in homes with fuse boxes? No. Certainly not. That would be negligent. Besides the fact that fuse boxes for homes are no longer sold, the electrical industry knows that breaker panels are generally considered better equipped to manage the increase power demands of the modern home today, thereby making them significantly safer to use compared to the fuse boxes of the past. Furthermore, electrical systems installed over 60 years ago would not meet the requirements in today's current edition of the NFPA 70 NEC Handbook. The NEC updates its standard code every three years primarily to incorporate new technologies, best practices for electrical construction, and above all to ensure safety to people and protect property from electrical hazards.

Likewise, the most current AASHTO LRFD or Revised AASHTO Standard Specifications must be applied to the design of highway structures like traffic signals rather than using dated older methods like ASD. As explained previously, the PA Pole and Mast Arm does not meet the AASHTO LRFD code criteria, specifically the fatigue requirement. The LRFD is considered a more advanced and safer design method compared to the ASD because it

includes a probabilistic approach to load factors allowing for more accurate representation of extreme weather events and their potential impact on a structure, making it better suited for modern design considerations. Like jurisdictions within the United States mandates electricians to adhere to the most current NEC handbook, the FHWA requires state DOTs to follow the most current editions of the AASHTO LRFD Specifications or AASHTO Standard Specifications. In addition to this, the Engineering Code of Ethics mandates engineers to prioritize public safety and use sound engineering practices which generally implies utilizing accepted and most current design methods like the LRFD that is considered more advance and safer than other design methods from the past.

Question: Is there anything from the PA Pole and Mast Arm design that carried over into the new standard design Post and Mast Arms- Type TS?

Answer:

Yes. One mainstay throughout MnDOT traffic signal structures design history has been the Vierendeel truss configuration type mast arm because of its successful history of in-service performance. MnDOT has found that its two-member truss style mast arms are not susceptible to galloping like so many other DOTs single member cantilevered tapered mast arm structures are prone to. Galloping refers to large, wind-induced vibrations in traffic signal pole mast arms that can significantly contribute to fatigue damage at the connection points between the mast arm and pole, due to the repetitive stress cycles caused by the oscillating movement.

More importantly the MnDOT mast arm design meets AASHTO LRFD specifications. The design of the PA and BA mast arm was able to be carried over into the new standard Pole and Mast Arms Type TS standard except for the change from the PA series multisided to round arm members, additional access opening points along the mast arm, and updates to connection points (mast arm to pole). And the TS 15-55 mast arms increased in diameter size compared to the PA series pole mast arms.

Question: What happened to MnDOT's Pole and Mast Arms-Type BA?

Answer:

In 2012, the series "BA" group of super-pole structures were introduced to accommodate mast arm lengths from 60 feet to 80 feet in 5-foot increments. Unlike the PA series Pole and Mast Arm, the BA series Pole and Mast Arms design did establish support for the combination of traffic signal heads and signs to be mounted on mast arms and included fatigue resistance provisions into the design that were current at that time. The BA series Pole and Mast Arm design was essentially a larger version of the new standard TS series post and mast arm design. With some minor modifications to the BA series Pole and Mast Arm design it eventually changed over to Post and Mast Arms Type TS 60' to 80'.

To help identify the new standards, MnDOT decided the old "PA" and "BA" jargon would not be used and the new standards identified as "TS" (Traffic Signal) series. The standard plates are categorized as follows:

- Post and Mast Arm Type TS-Mast Arm Assembly for Mast Arm Lengths 15' to 55' Standard Plate No. 8124. AKA "TS 15-55".
- Post and Mast Arm Type TS-Mast Arm Assembly for Mast Arm Lengths 60' to 80' Standard Plate No. 8125. AKA "TS 60 -80".

Question: Did the foundations for signal poles and mast arms change because of the new LRFD?

Answer:

Originally, MnDOT thought it would be bracing for massive changes due to the potential magnitude of the foundations that were initially speculated. And yes, as might be expected, the new foundations did see increases

in the depth, diameter size, and the amount of structural re-bar in comparison to the PA pole foundations. But surprisingly only moderately. This considering the new foundation design was based on:

- The AASHTO LRFD Code
- The new post and mast arms- Type TS 15'-55' overall structure is slightly larger in size than the PA series Pole and Mast arm.
- The mast arms are now designed to service both traffic signal heads and signs.

Based on these factors, naturally it would call for deeper and larger diameter foundations to ensure structural stability.

But the more noticeable changes and potential challenges for contractors and inspectors will be the required methods and necessary equipment used to construct the new foundations, and who will be required to construct them. You see, unlike the PA Pole and Mast Arm structure, the PA Pole Foundation has not performed as well over the last decade or more. MnDOT PA Pole Foundations have experienced tilting, shifting, and rotating in addition to settling and compaction issues with the surrounding soils. This may be due to several factors. Notably, the minimum 12-foot design depth of the foundations regardless of mast arm length used or sometimes what the drilled shaft soil conditions types were, the methods and practices used during the construction of the foundations such as the use of permanent full length concrete forming tubes, and increases in applied wind loads due to not just traffic signal heads, but large signs installed on mast arms that placed significant demands on the foundation's performance.

Question: The Post and Mast Arms-Type TS Standard Plates and the Pole Foundation Type TS Standard Plans were published in February 2024 and MnDOT is already making changes?

Answer:

Yes. Even though MnDOT Traffic Structural Standard Plans group sent out draft TS pole standard plates and TS pole foundation standard plans to stakeholders for review and comment well in advance before final draft and approval, the truth is the design of anything is never just a one-time event. Different stakeholders might review the design at different stages, bringing fresh perspectives and potential concerns that were not initially considered. Let's face it, sometimes things are not fully apparent at first or even second glances especially when it only exists in technical drawings.

There are several main reasons that drive the need for constant adaptations of designs. As signal designers begin to design signal intersections with the TS Post and Mast Arms and the TS Pole Foundations, as pole manufacturers begin to fabricate the TS post and mast arm structures, and eventually as contractors and inspectors begin to construct signal systems with the TS posts and mast arms and TS pole foundations, obviously there are going to be areas that require improvements and modifications along the way. As people further engage with the TS Pole and TS Pole Foundation, they will gain a deeper understanding how it should be constructed in their respective fields, leading to new observations and suggestions for refinement.

Many improvements and modifications to a design are apparent by just looking at the multiple versions of the PA series pole and foundation standard plates spanning over decades. Since its conception in 1968, the PA Pole and Mast Arm Standard Plate No. 8123 changed at least six times, the PA Transformer Base and Pole Base Plate Standard Plate No. 8121 changed at least seven times, the PA 90-100 Pole Foundation changed at least 11 times, and the PA 85 Pole Foundation changed at least a whopping 16 times. We say "at least" because these are just the recorded changes made. It is very possible there were more changes not recorded. And this does not include the other PA series pole and foundation related changes in other contract documents such as the MnDOT Standard Specifications for Construction Book.

CHAPTER 2 POLE FOUNDATIONS

Foundations are the first major part of any traffic control signal construction. They play a critical role in ensuring the stability and safety of the traffic signal structure. They are responsible for supporting and transferring the loads from the structure into the ground. Therefore, foundations must be designed to withstand the loads imposed on it by the structure, such as weight and other additional loads like wind while considering critical considerations including foundation type (drilled shaft, spread footing, etc.), depth, soil bearing capacity, and soil type.

This chapter describes the TS Pole foundation designs, types, categories, and other information related to materials and construction requirements necessary for the foundations to provide structural integrity for specific TS pole structure types. The foundation design process considered several factors to ensure that TS foundations are designed to withstand the loads and maintain the TS Pole structure's stability and safety. It is important to follow those construction requirements in contract documents for TS pole foundations and not circumvent required procedures and methods. A poorly constructed foundation can lead to problems like foundation settling, leaning, turning during high wind events, and even structural failure.

For general foundation construction information refer to Chapter 11, "Traffic Control Signal and Lighting Foundations and Equipment Pads" in the Signals and Lighting Field Guide. For general foundation construction requirements reference MnDOT Spec. 2401, "Concrete Bridge Construction". For TS Pole foundation's specifications consult the project's Division SS provisions. Construction specifications for TS Pole Foundations will be in the project's Division SS provisions for the next 5 years until published in the 2030 edition of the MnDOT Standard Specifications for Construction Book.

2.1 Foundation Designs and Types

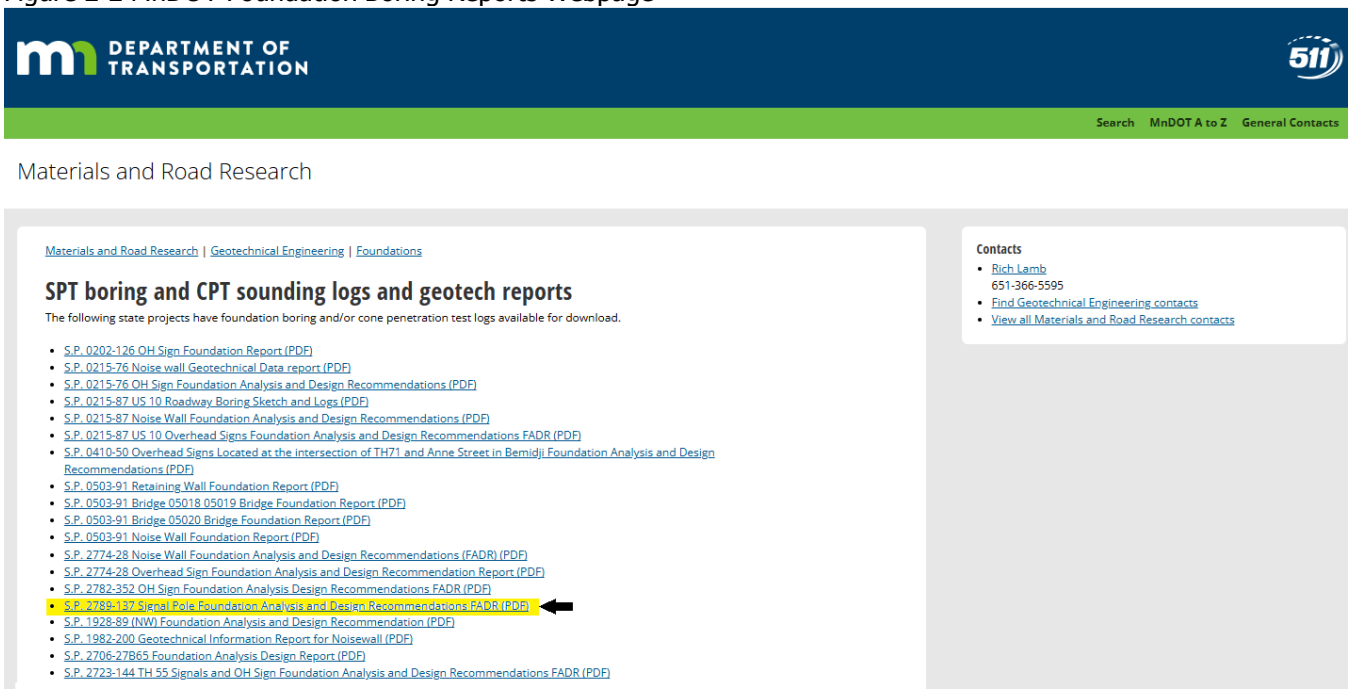
The two foundations designed for the TS Pole Foundation are the drilled shaft and the spread footing. The drilled shaft foundation is the standard that will typically be employed for TS Pole signal systems. The spread footing foundation will be used on a limited basis, determined by the MnDOT Geotechnical Engineering Section. Both foundation designs are required to be constructed by an experienced foundations contractor outlined in the Division SS provisions for the project.

The MnDOT Geotechnical Engineering Section during the P6 guidance for scoping projects will provide a PM to include activities for soil borings within 30 feet of the foundations by the MnDOT drill crew using a specialized geotechnical drill rig to extract soil samples. Based on the soil samples, a foundations report will be made available informing the signal designers and contractors which foundation, drilled shaft or spread footing, is required before the start of the project. Foundation boring reports for state projects can be accessed at MnDOT Foundation Boring Reports.

Figure 2-1 MnDOT Drill Rig

Based on mast arm length and soil boring results, the foundation's boring report should typically authorize for one of the predefined drilled shaft foundations shown on Standard Plan 861 "Drilled Shaft Foundation Data" table (Figure 2-4) to be used at TS Pole locations on the project. Environmental factors, such as soil conditions and water tables can play a significant role in the foundation design. There may be circumstances when the predefined drilled shaft foundations outlined on the Drilled Shaft Foundation Data table are not authorized to use because soil conditions are not ideal. In these situations, the MnDOT Geotechnical Engineering Section may prescribe in the project's foundation boring report to construct a deeper drilled shaft than the typical predefined depths shown on the table.

Figure 2-2 MnDOT Foundation Boring Reports Webpage



There also may be occasions when it is determined that a spread footing is necessary during the project once the foundation excavation begins because initial borings did not detect shallow bedrock or locates did not show utility conflicts. In any event, the decision to opt for a spread footing cannot be exclusively made by the contractor. The contractor must seek approval from the district soils engineer and project engineer before constructing a spread footing instead of a drilled shaft.

The detail drawings for the drilled shaft and spread footing TS pole foundations can be found on Standard Plan 5-297.861 "Pole Foundation Type TS" also called "Standard Plan 861". The Pole Foundation Type TS Standard Plan designates the foundations into four categories as follows:

- Spread Footing for 15' to 55' Mast Arms
- Drilled Shaft Foundations for 15' to 55' Mast Arms
- Spread Footing for 60'-80' Mast Arms
- Drilled Shaft Foundations for 60'-80' Mast Arms

From there each foundation category is further divided into specific foundations based on the TS Pole type (mast arm length) as shown in Figures 2-3 and 2-4 Foundation Data tables. These tables have been updated and do not reflect what is currently shown on Standard Plan 861. It was decided to merge the foundations from four categories to two categories of Pole Foundations Type TS 15' to 55' Mast Arms for drilled shafts and spread footings.

As demonstrated on the Foundation Data tables in this publication the foundation required to be installed corresponds with the mast arm length (TS Pole type) being installed on the project. This is important to follow since foundation depths and diameter sizes are based on mast arm sizes and wind loads. Do not intermix TS Pole Foundation types with TS Pole types except what is currently required for the project.

Figure 2-3 TS Pole Spread Footing Foundation Data

POLE FOUNDATIONS TYPE TS
SPREAD FOOTING FOR 15' TO 55' MAST ARMS

SPREAD FOOTING FOUNDATION DATA					
POLE TYPE	MAST ARM LENGTH	SPREAD FOOTING DIMENSIONS			
		A	B	C	D
TS15-TS40	15' 0", 20' 0", 25' 0" 30' 0", 35' 0" & 40' 0"	9' 6"	3' 3"	3' 0"	9' 0"
TS45-TS55	45' 0", 50' 0" & 55' 0"	11' 0"	3' 6"	4' 0"	10' 6"

POLE FOUNDATIONS TYPE TS
SPREAD FOOTING FOR 60' TO 80' MAST ARMS

SPREAD FOOTING FOUNDATION DATA				
POLE TYPE	MAST ARM LENGTH	SPREAD FOOTING DIMENSIONS		
		A	B	C
TS60	60' 0"	12' 6"	4' 0"	12' 0"
TS65	65' 0"	13' 0"	4' 3"	12' 6"
TS70	70' 0"	14' 0"	4' 9"	13' 6"
TS75	75' 0"	15' 0"	5' 3"	14' 6"
TS80	80' 0"	15' 6"	5' 6"	15' 0"

Figure 2-4 TS Pole Drilled Shaft Foundation Data

POLE FOUNDATION TYPE TS
DRILLED SHAFT FOUNDATIONS FOR 15' TO 55' MAST ARMS

DRILLED SHAFT FOUNDATION DATA			
DESCRIPTION	DIMENSION	MAST ARM LENGTH	
		15' TO 40'	45' TO 55'
SHAFT DIAMETER	F	3' 0"	4' 0"
FOUNDATION BURIED DEPTH	G	13' 0"	14' 0"
BOLT CIRCLE DIAMETER	$\emptyset_C$	1' 9"	1' 9"

POLE FOUNDATION TYPE TS
DRILLED SHAFT FOUNDATIONS FOR 60' TO 80' MAST ARMS

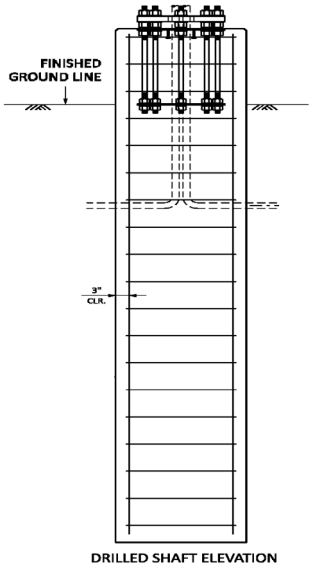
DRILLED SHAFT FOUNDATION DATA						
DESCRIPTION	DIMENSION	MAST ARM LENGTH				
		60'	65'	70'	75'	80'
SHAFT DIAMETER	F	4' 6"	4' 6"	4' 6"	4' 6"	4' 6"
FOUNDATION BURIED DEPTH	G	14' 0"	16' 6"	19' 6"	22' 0"	24' 6"
BOLT CIRCLE DIAMETER	$\emptyset_C$	2' 5"	2' 5"	2' 7"	2' 9"	2' 9"

While perpetually modifying the TS foundation and pole design is unfortunate and frustrating for all stakeholders involved in the design and construction of new TS Pole Systems, it is also an innate process of any new design to have continuous adjustments and updates for an unknown length of time based on user feedback and other evolving factors. For that reason, even though MnDOT OTE Signals and Lighting intends for this publication to be a relevant and useful guide, always consult the project's contract documents for the most current requirements at the time of design.

2.1.1 Drilled Shaft

Drilled shaft foundations are used because of their very high load capacities. A drilled shaft is a cylindrical excavation that penetrates through the weak soils to get to more stable layers of soil and then filled with concrete. The concrete is placed in the shaft without a permanent casing, so the concrete contacts the surrounding soil for the primary purpose of structural support. One of the most important aspects of the interaction between the poured concrete and the surrounding soil is that it creates a resistance to lateral force or load, such as lateral resistance to wind.

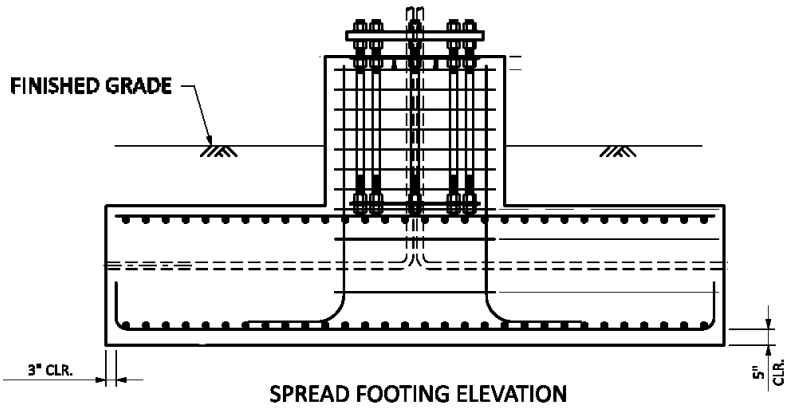
Figure 2-5 Drilled Shaft Foundation



2.1.2 Spread Footing

Spread footing foundations have a wider bottom when compared to a drilled shaft, designed to distribute the weight of the TS Pole structure over a larger area of soil, thereby reducing the pressure on the underlying ground and preventing settlement and tilting. Spread footings are considered “shallow foundations” because they are placed closer to the surface of the ground and do not need to reach as deep as drilled shafts. However, a spread footing requires a larger excavation footprint, which can be problematic in situations where space is limited, like in an urban setting, making it impractical to use for signal intersections located in densely developed infrastructure areas.

Figure 2-6 Spread Footing Foundation



2.2 TS Pole Foundation Hardware

Besides the primary materials that make up a basic pole foundation, such as concrete, reinforcement bars, anchor rods to secure the pole, and conduits to route the electrical wiring, the new TS Pole Foundations features several additional components. Even though these additional components and hardware installations may not be new to contractors, they are to a certain degree new to MnDOT signals construction. The following in this subsection identifies some of those additional components and hardware installations that are new to signal foundation construction.

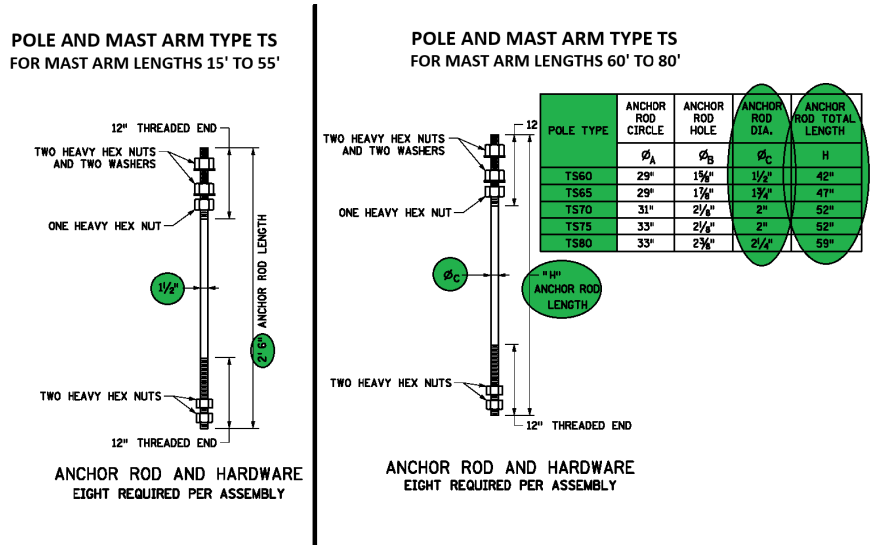
2.2.1 Anchor Rods and Anchor Rod Assemblies

Different from the required anchor rods and hardware that many people are used to seeing on the foundation standard plates for the PA series, the requirements and details for the anchor rods and hardware for the TS Pole foundations are shown with the poles (steel) on the Post and Mast Arm Type TS Standard Plate No. 8124 and 8125 "Anchor Rod Assembly Details" page.

For information on anchor rods and hardware material, and the anchor rod assemblies, reference the TS Pole standard plates (Post and Mast Arm Type TS Standard Plate No. 8124 and 8125). For information on installing the anchor rod assemblies in the foundations reference Pole Foundations Type TS Standard Plan 5-297.861. The rationale behind placing the foundation's anchor rod assembly in the standard plate is two-fold. One, most of the steel materials that are provided by the pole manufacturers should be combined into one standard document. And two, steel components like anchor rods and anchor rod assemblies are manufactured in a facility. MnDOT Office of Traffic Engineering (OTE) Signals and Lighting Unit has made a concerted effort in the past few years to coordinate manufactured/facility provided products in standard plates and field assembly products like the actual foundation construction in standard plans. This is a loose interpretation of standard plates versus standard plans that MnDOT OTE Signals and Lighting Unit generally adheres to and not an absolute as there are always exceptions.

In addition to Type B anchor rods and other requirements shown on Standard Plates No. 8124 and No. 8125 "Anchor Rod Assembly Details", you will find the anchor rod diameters and lengths required for specific TS Pole Types. In Standard Plate No. 8124, anchor rods for TS Poles using mast arm lengths 15' to 55' will all require a 1½" diameter straight anchor rod with a length of 2'6" and for TS Poles using mast arm lengths 60' to 80' there isa table provided that breaks down the required various anchor rods diameter sizes and lengths for each TS Pole Type as shown in the following Figure 2-7.

Figure 2-7 Anchor Rod Diameters and Lengths with Corresponding TS Pole Types



POLE TYPE	ANCHOR ROD CIRCLE ØA	ANCHOR ROD HOLE ØB	ANCHOR ROD DIA. ØC	ANCHOR ROD TOTAL LENGTH H
TS60	29"	1⅝"	1½"	42"
TS65	29"	1⅞"	1¾"	47"
TS70	31"	2⅛"	2"	52"
TS75	33"	2⅛"	2"	52"
TS80	33"	2⅜"	2¼"	59"

As mentioned, there is an anchor rod assembly required on the TS pole standard plates and shown on the TS

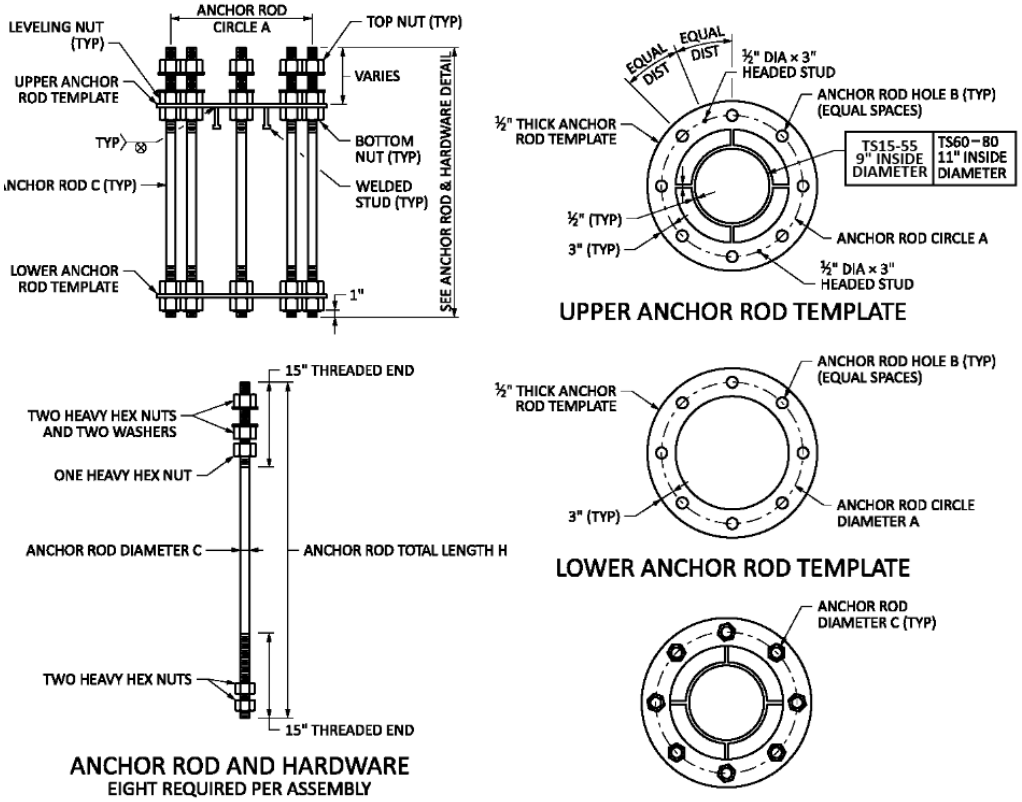
pole foundation standard plan on how they are installed. The majority of MnDOT standard lighting and signal pole foundations will now require an anchor rod assembly cast in the foundation. This is a departure from the traditional "L" hook type anchor rods that so many contractors had installed in MnDOT pole foundations for decades. The anchor rod assemblies consist of straight anchor rods with upper and lower anchor rod templates. The assemblies will more than likely be provided by the pole manufacturers and their discretion on how the materials for the assemblies are shipped to the project sites, either fully assembled or components shipped separately to be assembled in the field.

A frequent question concerning the straight anchor rods is if the entire length of the anchor rod is required to be galvanized? The answer is "yes" the entire length of the anchor rod is required to be hot dipped galvanized for service life requirements. Anchor rods that are only partially galvanized will not be accepted. The upper and lower anchor rod templates are required to be galvanized in accordance with MnDOT Spec. 3394 and heavy hex nuts and washers galvanized in accordance with MnDOT Spec. 3392. This means the entire surface of the anchor rod assembly is hot dipped galvanized regardless that most of the assembly will be cast in concrete.

For further details and information on the anchor rods and anchor rod assembly materials for TS Poles refer to:

- Post and Mast Arm Type TS Standard Plate No. 8124, "Anchor Rod Assembly Details for Mast Arm Lengths 15' to 55'" (10 of 12)
- Post and Mast Arm Type TS Standard Plate No. 8125, "Anchor Rod Assembly Details for Mast Arm Lengths 60' to 80'" (11 of 13)

Figure 2-8 Hardware for Anchor Rod Assembly



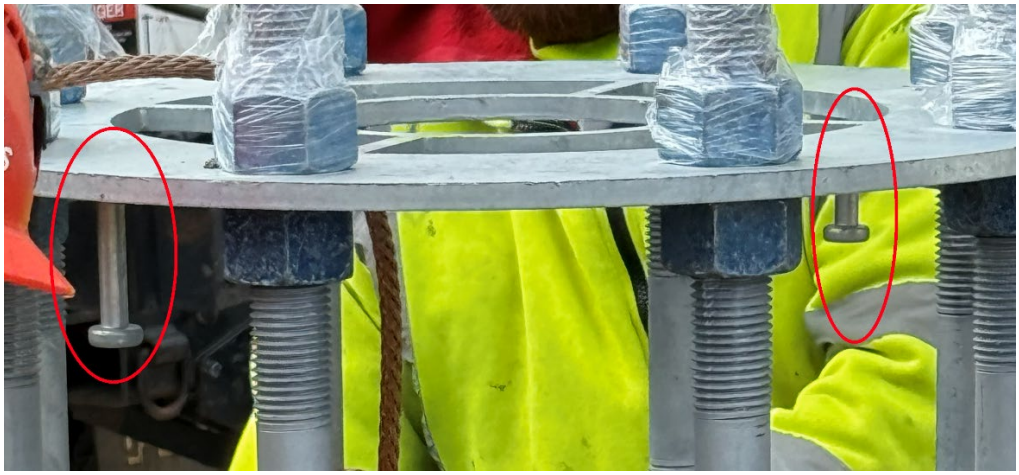
POLE TYPE	ANCHOR ROD CIRCLE	ANCHOR ROD HOLE	ANCHOR ROD DIA	ANCHOR ROD TOTAL LENGTH
	A	B	C	H
TS15-55	21"	1⅝"	1½"	30"
TS60	29"	1⅝"	1½"	42"
TS65	29"	1⅛"	1¾"	47"
TS70	31"	2⅛"	2"	52"
TS75	33"	2⅛"	2"	52"
TS80	33"	2⅜"	2¼"	59"

For guidance on foundation construction related items of anchor rods and anchor rod assemblies proceed to the TS Pole Foundations Construction section in this chapter, Pole Foundation Type TS Standard Plan 5-297.861 (5 of 5), and the project's Division SS provisions.

2.2.2 The Anchor Rod Assembly's Upper Anchor Rod Template

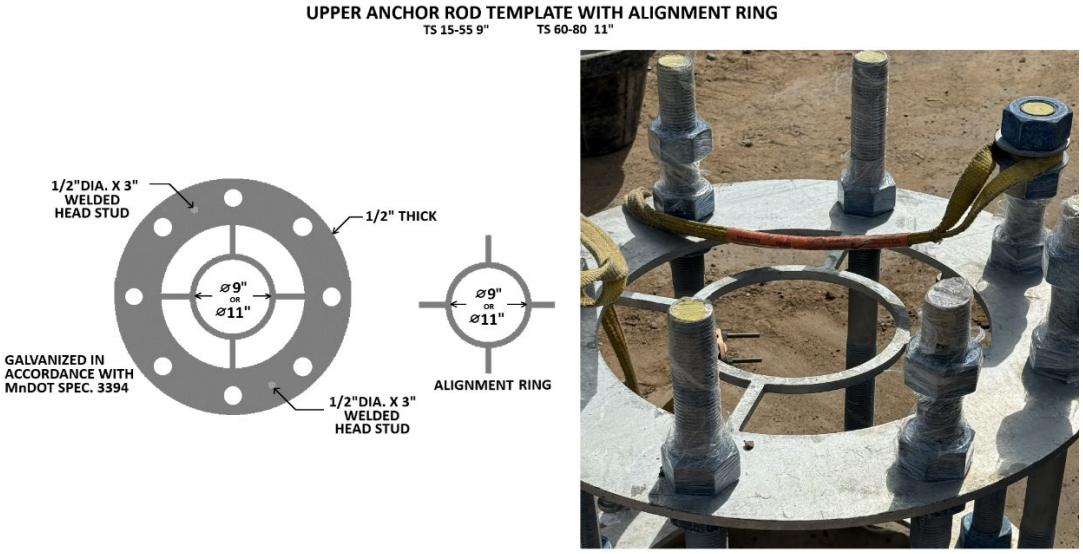
The upper anchor rod template has two welded studs on the bottom side of the plate for the purpose of casting in the concrete when installing the upper anchor rod template flush with the top of the foundation. This is to help hold the plate in the cured concrete once the hold down nuts are removed to be used for the pole's leveling (bottom) nuts.

Figure 2-9 Hardware for Anchor Rod Assembly



The upper anchor rod template has a 9-inch inner diameter alignment ring for the TS 15-55 10-inch base plate opening and an 11-inch inner diameter alignment ring for the TS 60-80 12-inch base plate opening. This is for centering the PVC conduit couplings projecting from the foundation top allowing the conduit stubs to fit through the base plate opening and inside the pole eliminating conduit misalignments and still provide some space between the base plate and conduits to install rodent intrusion barrier. The upper anchor rod template will be cast flush with the top of concrete including the alignment ring.

Figure 2-9 Alignment Ring Included with the Upper Anchor Rod Template



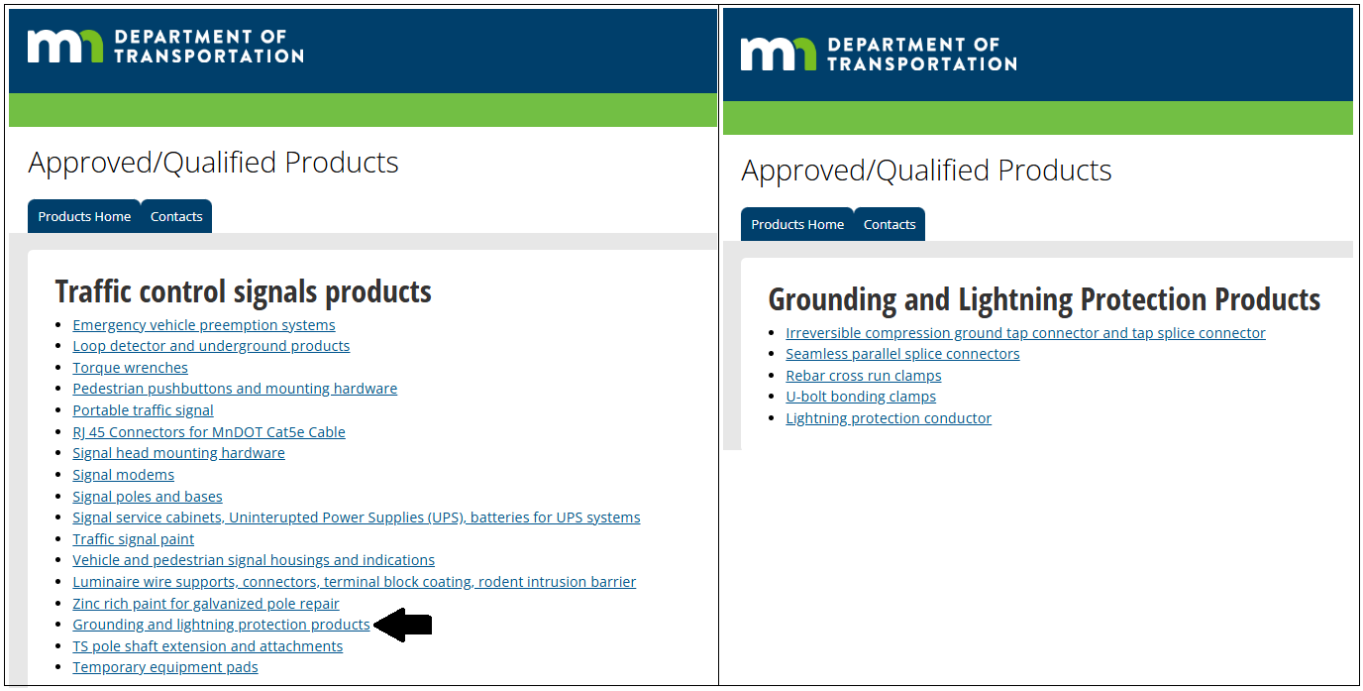
2.2.3 Lightning Protection Systems Hardware

To prevent lightning strikes from causing direct physical damage to sensitive signal systems electronics MnDOT has integrated a lightning protection system into the TS Pole foundations. This may be referred to as a concrete-encased electrode (CEE) or as known to some a "Ufer ground". Even though it's hard to predict where lightning will strike, there is a higher chance it will hit taller objects like traffic signal poles. Having a lightning protection system in the pole's foundation provides a means for the lightning strike to follow and enables the lightning current to dissipate quickly into earth, thereby preventing it from spreading further down the line through the signal system's electrical components and potentially causing further damage down the line to the traffic control signal cabinet's electronics.

In accordance with the National Electrical Code, TS Pole Foundation's lightning protection grounding system will be bonded together and connected to the signal system's primary grounding located in the signal service cabinet and equipment pad by way of the system's EGC and TS Pole to TS Pole foundation anchor rod connections. See Chapter 5 Traffic Signal Systems Grounding for bonding the LP system to the traffic signal system's grounding.

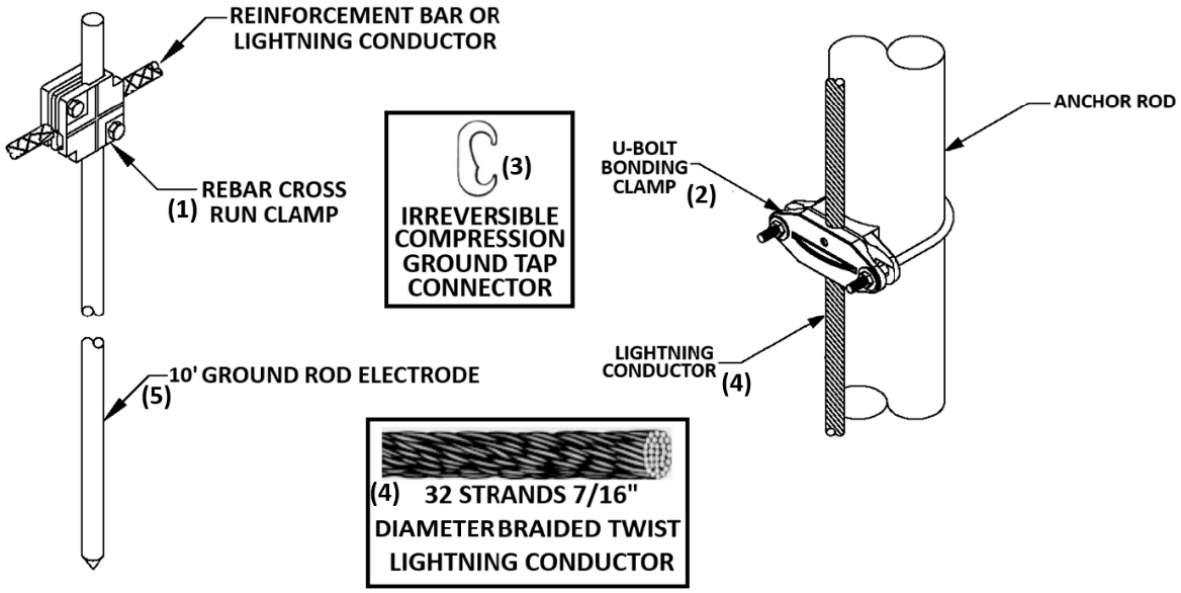
The required hardware for physically connecting and electrically bonding the foundation's rebar, anchor rod assembly, ground rod electrode, and lightning conductor for the purpose of constructing a lightning protection grounding system is found on MnDOT's APL- Signals **"Grounding and Lightning Protection Products".**

Figure 2-10 MnDOT's APL for Grounding and Lightning Protection Products



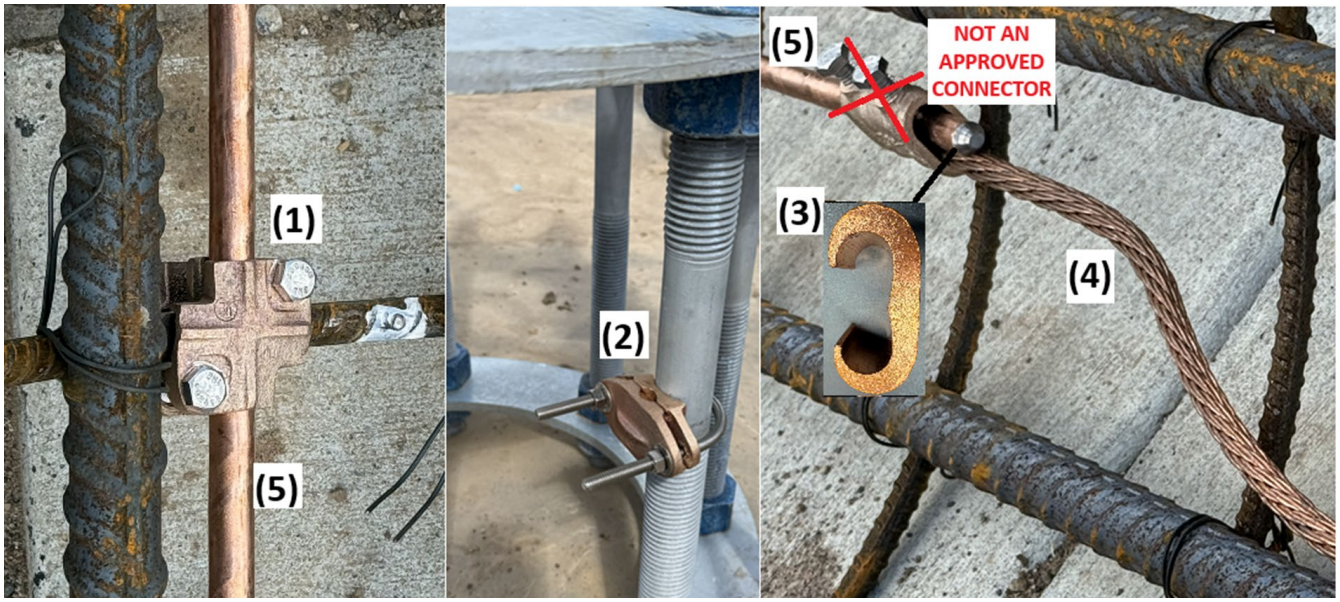
The specified hardware and components necessary to assemble a lightning protection system in a TS Pole foundation are as follows:

Figure 2-11 Lightning Protection Hardware for TS Pole Foundations



- **(1)** Rebar Cross Run Clamps- for connecting LP conductor or ground rod electrodes to the reinforcement bar.
- **(2)** U-Bolt Bonding Clamps- for connecting LP conductor to the anchor rod assembly.
- **(3)** Irreversible Compression Grounding Connectors- for connecting LP conductors to ground rod electrodes.
- **(4)** Lightning Protection Conductor- (LP Conductor)
- **(5)** 10-foot ground rod electrodes in accordance with **MnDOT Spec. 3818**.

Figure 2-12 LP Protection Systems Hardware



The hardware requirements for lightning protection systems in TS Pole Foundations will be included in Division SS provisions. For guidance on lightning protection systems construction in foundations proceed to the TS Pole Foundations Construction section in this chapter.

2.3 TS Pole Foundations Construction

With the introduction of the new Post and Mast Arm Type TS, it could have been presumed the primary subject of this publication would be more about the TS Poles. However, the central topic and possible point of contention is not the TS Poles themselves, but rather the Pole Foundation Type TS. The differences in how PA Pole Foundations were constructed compared to how TS Pole Foundations will be constructed are notably different in several ways. TS Pole Foundation construction will:

- Require experienced drilled shaft foundation contractors for both drilled shafts and spread footings.
- Have a spread footing design ready to use with approval.
- Not allow the use of full-length permanent casings and forming tubes for drilled shaft foundations.
- Require a lightning protection system in the foundations.
- Require a visual inspection of lightning protection before and during concrete pour operations.
- Require an anchor rod assembly in the foundation.
- Require a concrete stamp to ID the foundation.

With these new foundation requirements, MnDOT Signals is entering into uncharted territory for all involved in signal construction. The TS Pole Foundation construction is more complex than the old PA Pole Foundations, involving multiple stakeholders, necessitating everyone to work together efficiently to achieve sound and

durable foundations with lightning protection in accordance with the contract documents. It will be a rigorous process with challenges for all but especially for the electrical contractors as they must coordinate with the experienced drilled shaft contractors and provide the district traffic office visual inspection while installing the lightning protection system all during concrete pouring operations.

The following subsections focus on the more important key details of the new TS Pole Foundation construction, essentially summarizing the core ideas for general guidance without going into the specifics. For specifics on TS Pole Foundation construction refer to Division SS provisions and Standard Plan 861.

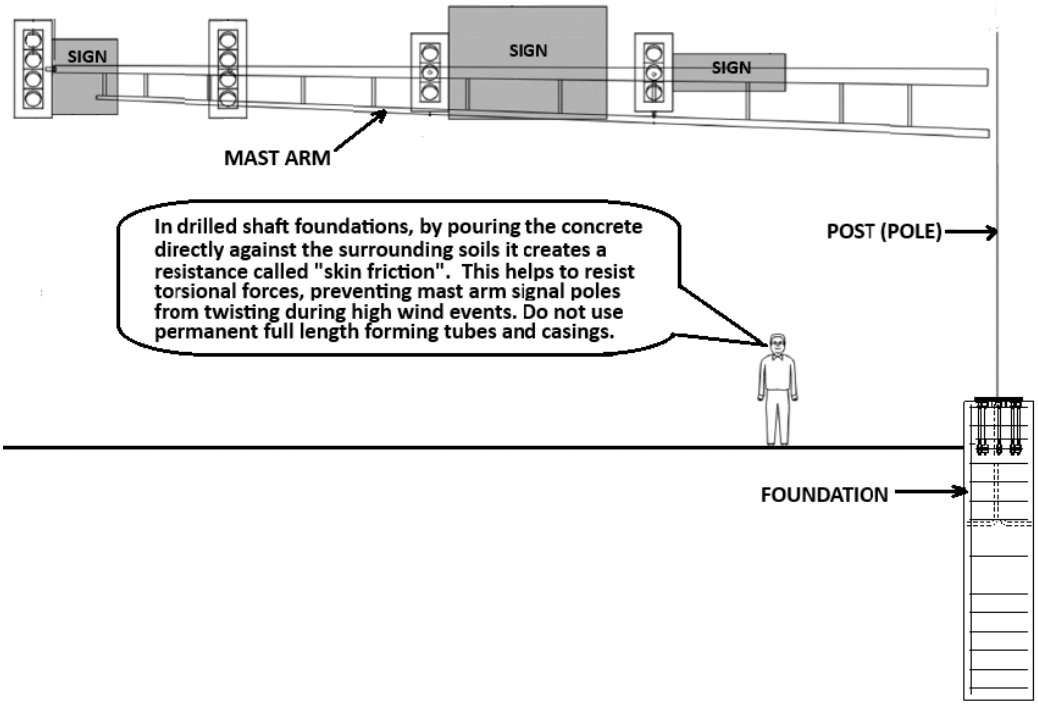
2.3.1 Concrete Forming Tubes, Liners, and Casings

The practice of using full-length permanent forming tubes and casings including corrugated metal culverts for MnDOT mast arm signal pole drilled shaft foundations is no longer allowed. A partial permanent casing for the upper portion of the foundations as specified in contract documents will still be necessary to use. For drilled shaft TS Pole Foundations 15’ to 60’ a partial permanent casing may be used for the first 4 feet of the drilled shaft below finished grade or sidewalk. For TS Pole Foundations 65’ to 80’ a permanent casing may be used for no more than 25 percent of the total foundation depth below finished grade. If using steel corrugated pipe, ensure the corrugation does not interfere with the reinforcement bar 3-inch clearance concrete coverage. The allowable partial forming tube does not include the 2’ 3” (27 inches) of foundation projection required above grade or sidewalk. Obviously, some type of form is necessary to form the concrete above grade or sidewalk. Use smoothed wall concrete forms for the foundation projection above grade or sidewalk.

Figure 2-13 Partial Forming Tube

This is not to imply that all drilled shaft foundations should never use full-length permanent casings, they are simply not allowed to be used in drilled shafts for TS Pole Foundations. Permanent casings can significantly reduce the available soil resistance for the drilled shaft, adversely impacting the foundation's load-carrying and torsional resistance capacities. This applies especially to foundations that are attached to steel pole structures with very long cantilever arms for mounting signal heads and signs. For signal mast arm poles it should come as no surprise that a foundation with high torsional resistance to withstand significant twisting moment is extremely important. As previously mentioned in Chapter 1 Introduction, many MnDOT PA Pole Foundations using full-length permanent casing have experienced tilting, shifting, and rotating in addition to settling and compaction issues with the surrounding soils. The widespread use of full-length permanent casings in the construction of the PA Pole drilled shaft foundations is the fundamental cause for many of these issues raised.

Figure 2-14 Mast Arm Loading and Drilled Shaft Foundation Construction

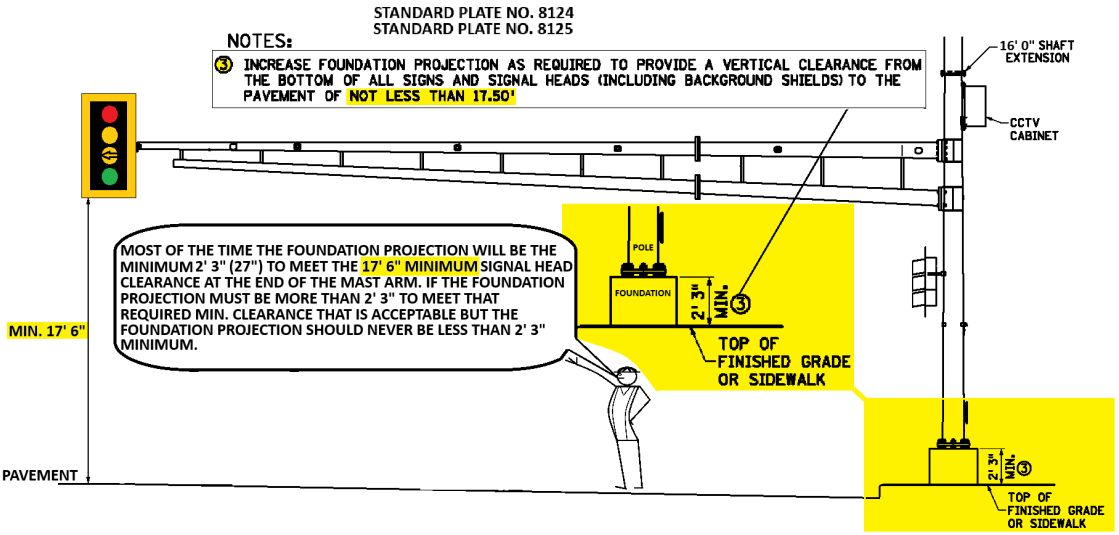


The determination to use the TS Pole spread footing foundation will be made by MnDOT based on the foundation boring report. There may also be occasions where the foundation soils boring report did not recommend a spread footing foundation before the start of the project, but later during excavation it was discovered that a spread footing may be the better option over the drilled shaft. The decision to opt for a spread footing once the project has started cannot be exclusively made by the contractor. The contractor must seek approval from the district soils engineer and project engineer before constructing a spread footing instead of a drilled shaft.

2.3.2 Minimum 2’ 3” (27”) Foundation Projection

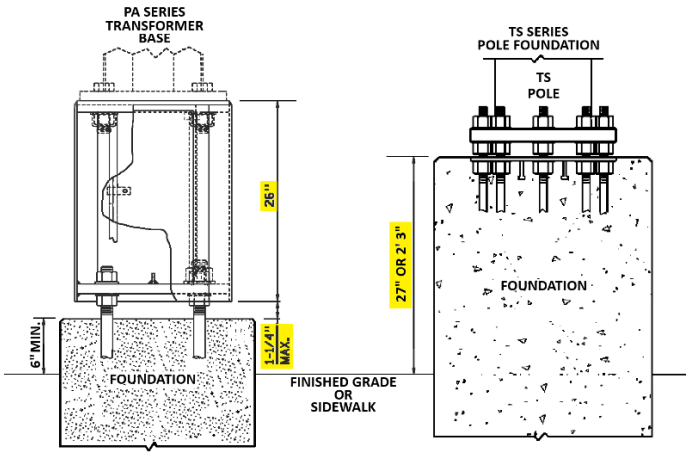
As stated before, the foundations are required to extend above the finished grade or sidewalk a minimum 2-feet 3-inches. A fiberboard or cardboard inner smooth wall form is necessary to mold or shape the exposed portion of the foundation above ground. The temporary form can be removed any time following the 7-day curing period after concrete pouring operations.

Figure 2-15 2' 3" (27") Foundation Projection and Signal Head Clearance



Why is the TS Pole Foundation projection above ground a minimum 2 foot-3 inches or 27 inches? The projection is related to the old PA Series Transformer Base (T-Base) height which is approximately 27 inches when mounted on the foundation anchorages (T-Base 26" + set anchorage leveling nuts = approximately 27"). When nuisance rubs and minor damage to the PA T-Bases would occur from maintenance equipment or errant vehicles, maintenance could simply replace the T-Base with a new one by unbolting and separating the T-Base from the main pole or post by hoisting the pole and mast arm a couple of feet. With the new TS Poles, the base is the base of the pole with a baseplate at the bottom that is integrated with the pole as one whole piece. If minor damage takes place to the base of the TS pole, the entire pole must be replaced by taking down and separating the vertical pole from the mast arm. To do this would be a large-scale operation for maintenance and requiring a longer road closure period. Therefore, the minimum 27-inch foundation projection is mainly for protecting the pole since it is easier to repair superficial concrete damage to the foundations than it is to change out an entire pole. Keep in mind, when high-speed impact vehicle hits occur, both foundations and overhead traffic signal structures are typically damaged beyond any repair. These overhead traffic signal structures are not designed to breakaway, because if an overhead structure of this size detaches from its foundation caused by a vehicle, it could become a dangerous falling structure, potentially causing further damage to property and injury to pedestrians, motorists, and passengers. The goal is to design traffic signal structures to withstand high-speed impacts as much as possible while minimizing potential harm.

Figure 2-16 TS Pole Foundation has a Minimum 27" Projection Because the PA T-Base Mounted Height is 27"



2.3.3 Experienced Drilled Shaft Contractors

Because TS Pole Foundation drilled shafts are considered complex to build due to their reliance on drilling techniques, specialized equipment, and sensitivity to ground conditions, only experienced foundation contractors are permitted to perform foundations work for TS Poles. Experienced drilled shaft installers (crew) must have a minimum of 5 years' experience in wet method and temporary casing method drilled shaft installations and have successfully completed construction of shafts with similar site and subsurface conditions, shaft diameter, and shaft depths.

NOTE: Foundation construction experience of PA Pole foundations does NOT count towards 5 years' experience in wet method and temporary casing method drilled shaft installations since PA Pole foundation drilled shaft construction methods used permanent full length forming tubes. Provide verifiable documentation demonstrating a minimum of 5 years of journey-level foundation work experience that includes the applications of the wet method and temporary casing method.

Wet method and temporary casing method are techniques used when dry excavation cannot be maintained typically due to high water tables and poor soil conditions that otherwise cave into the shaft. These techniques allow for the concrete to be poured directly against the soil of the drilled shaft while preventing the shaft from collapsing without the use of a permanent full-length forming tube, casing or culvert.

Figure 2-17 Temporary Casing

The foundation contractor's supervisor is required to have a minimum of 3 years' experience in construction of drilled shaft construction methods. The contractor's foundation supervisor credentials will be included in the required Foundations Construction Work Plan submittal to the engineer for review. Improper installation can significantly impact the structural integrity of the foundation; essentially, TS Pole Foundation construction requires a high level of skill to keep the drilled shaft open during concrete operations, and the experience to ensure quality and safety.

The Foundations Construction Work Plan submittal is a formal contract document used to affirm that the contractor's foundation installers (crew and supervisor) possess the necessary expertise, experience, and

equipment to execute the specialized task of pouring TS Pole foundations as specified in the contract. Engineer's approval of the submittal does not relieve the contractor's responsibility to construct TS pole foundations as required by the contract documents.

Essentially, the contractor is verifying their crew and supervisor included in the submittal have the competence in constructing the foundations according to the contract documents. If the dry drilled shaft method fails due to unstable soils, the contractor has the confidence of their crew and supervisor to successfully implement the wet method or temporary casing method. Contingency plans involving permanent full-length forming tubes of any material type, full length casings of any material type, or full-length culverts of any material type are strictly prohibited.

Opting out of installing drilled shaft foundations in lieu of TS Pole spread footing foundations to evade employing an experienced drilled shaft contractor is not possible since Division SS provisions require only qualified and experienced drilled shaft installers are permitted to perform foundations work (drilled shafts and spread footings) and the contractor must seek approval from the district soils engineer and project engineer before constructing a spread footing instead of a drilled shaft.

2.3.4 Foundations Construction Work Plan

At the project's preconstruction meeting, the contractor will submit to the engineer and the signal district traffic office a "Foundations Construction Work Plan". As mentioned previously, the drilled shaft contractor's credentials will be included in the work plan along with the following information.

(1) Provide the drilled shaft construction methods to be used or state "Spread Footing Foundation Type TS__".
(2) Proof that drilled shaft installer qualifications have been met, including a list of similar projects completed in the last 3 years with names and contact information of installer representatives who can verify participation in those projects.
(3) Name and experience record of the drilled shaft installer supervisor.
(4) Proposed construction method procedures of the following:
    a) Excavation
    b) Cleaning
    c) Inspection
    d) Placement of temporary casings
    e) Removal of temporary casings
    f) Placement of reinforcement with required lightning protection
    g) Placement of anchor rod assembly and connection to required lightning protection
    h) Description of supports for anchor rod assembly and conduits
    i) Schedule and sequence of construction operations
    j) Plan for containments and clean-up of any spills or discharge of material that may accidently or deliberately enter the environment

The engineer will review the plan within 14 Calendar Days of the submittal and provide written instructions if changes are necessary to meet contract requirements. Once approved, if afterwards revisions to the plan are necessary, obtain engineer's approval before implementation of the revised work.

The engineer's approval of the foundation construction work plan and revisions does not relieve the contractor's responsibility to provide a safe work environment and successful completion of drilled shafts and foundations in accordance with the contract.

The contractor is required to produce sound, durable concrete drilled shaft foundations free of defects and

anomalies using dry method, wet method, temporary casing method, or combinations thereof as proposed in the Foundations Construction Work Plan. The drilled shaft installer may increase shaft diameters and depths of the required shaft dimension to conform to their equipment or to expedite drilling operations, but no additional compensation will be paid unless the increase was ordered by the engineer.

2.3.5 Concrete Placement in Drilled Shafts

Historically, PA foundations did not mandate specific concrete placement method for drilled shafts. However, current TS Pole Foundations require the use of a tremie, concrete pump, or other approved placement methods in accordance with MnDOT Spec. 2401.3C “Placement of Concrete – General Requirements”. This prevents concrete segregation, the separation of aggregate from cement paste, and ensures a continuous flow around the reinforcement without contacting the excavation sides, thereby preserving the shaft’s structural integrity.

Figure 2-18 Concrete Placement

2.3.6 TS Pole Foundation Lightning Protection (LP) Systems

To safeguard the signal systems electronic equipment a lightning protection system is required to be installed in each of the TS Pole Foundations to provide a path to earth for lightning transients using the approved bonding clamps, irreversible compression grounding connectors, and lightning protection conductor covered in the “Lightning Protection Systems Hardware” section of this publication.

Figure 2-19 LP System Hardware

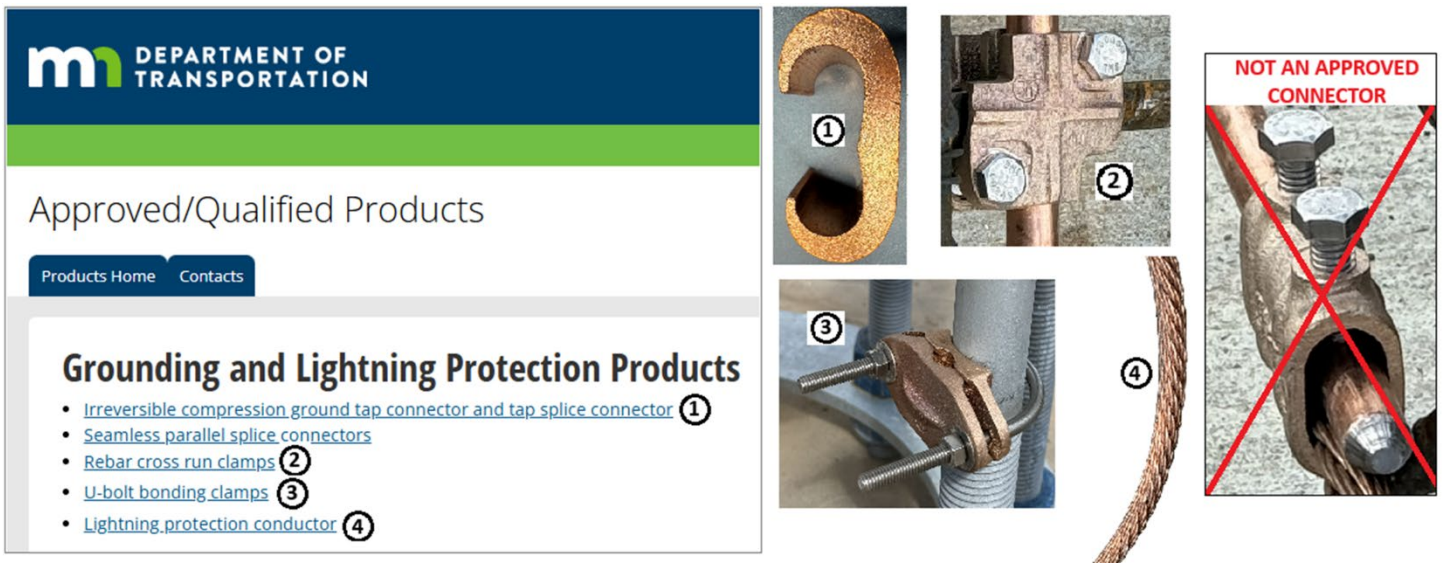
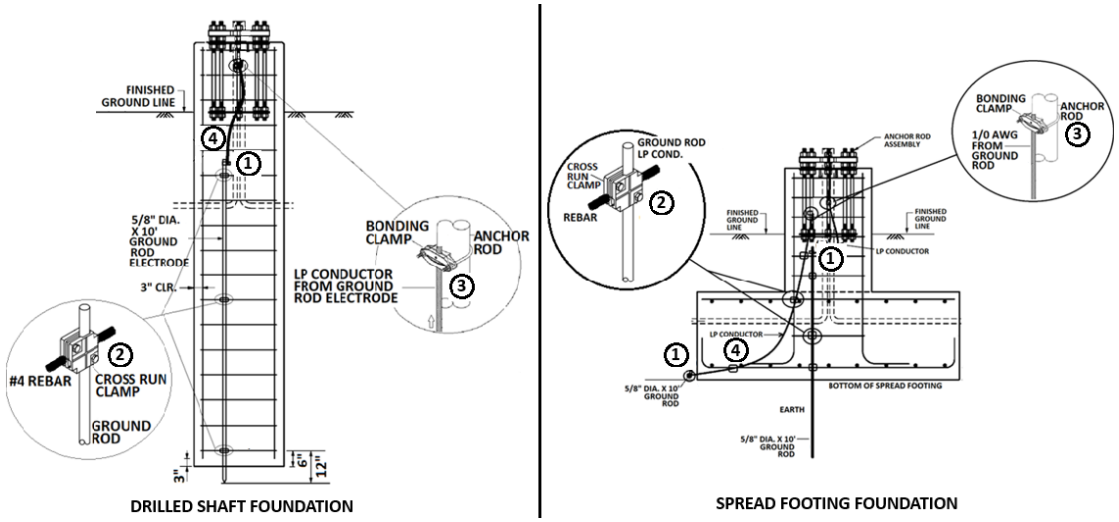


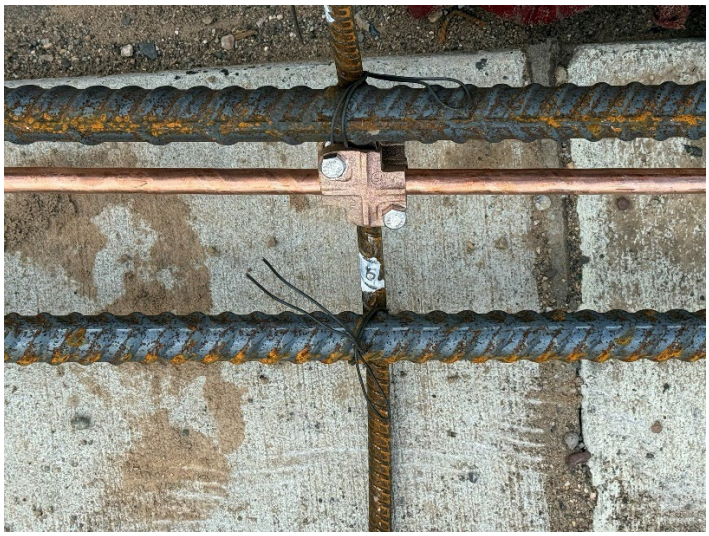
Figure 2-20 LP Systems for Drilled Shaft and Spread Footing Foundations



Grounding continuity of the TS Pole's steel structural components can be achieved without using dedicated bonding wires and lightning down conductors for air terminals, simply by relying on the inherent conductivity of the galvanized metal when parts are mechanically connected with high strength bolts and anchor rods, creating a sufficient electrical connection to ensure the continuity throughout the TS Pole structure and to the foundation's lightning protection system.

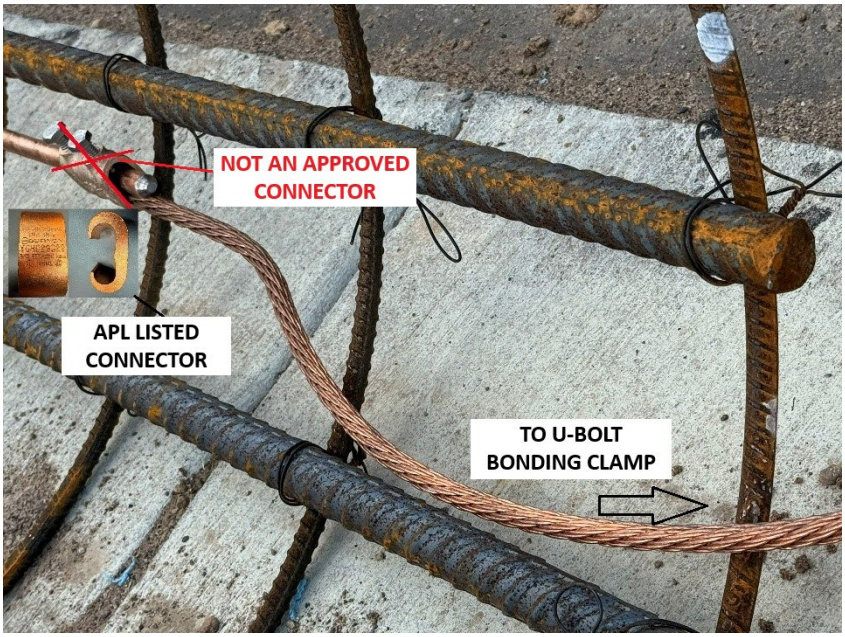
As stated previously in the "Lightning Protection Systems Hardware" section of this publication, the LP systems in foundations are Ufer grounds. The ground rod electrode attached to the reinforcement bar that is connected using cross run clamps is listed on MnDOT's APL- Signals.

Figure 2-21 Rebar Cross-Run Clamps



At the top of the ground rod electrode a length of LP conductor listed on MnDOT's APL- Signals is connected using an irreversible compression connector listed on MnDOT's APL- Signals.

Figure 2-22 Wrong Connector/Use an Irreversible Compression Connector



Provide enough LP conductor length to be able to reach an anchor rod in the assembly for attaching the other end with a U-Bolt bonding clamp listed on MnDOT's APL- Signals just before casting the assembly in concrete.

Figure 2-23 U-Bolt Bonding Clamp on TS Anchor Rod Assembly

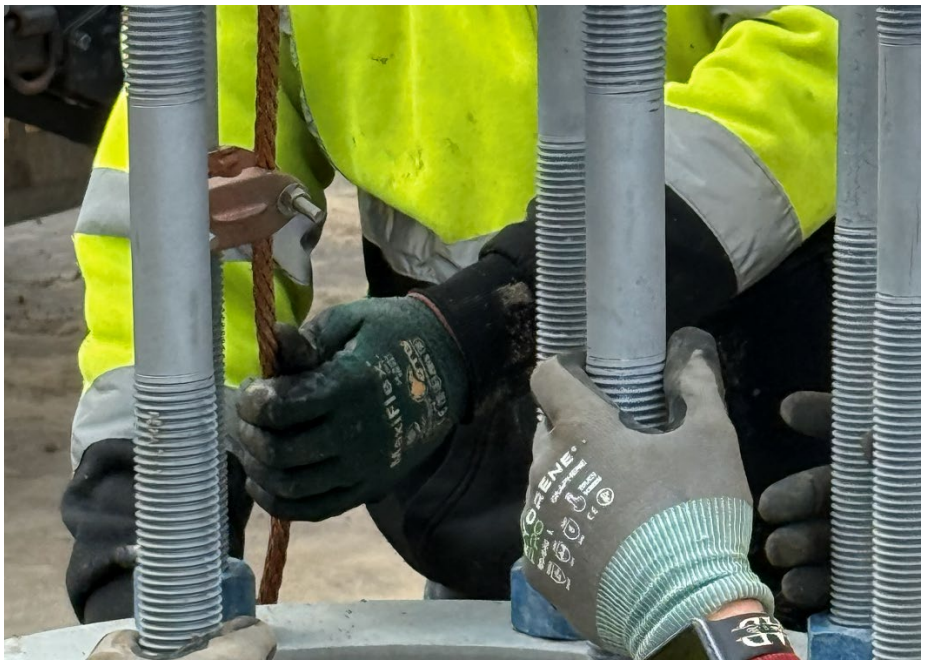


Figure 2-24 Dead End LP Conductor After Connecting With U-Bolt Bonding Clamp

DEAD END LP CONDUCTOR AFTER CONNECTING TO U-BOLT	DO NOT BRING LP CONDUCTOR UP TO THE SURFACE OF THE FOUNDATION

2.3.7 Lightning Protection for Painted TS Poles

Pole fabricators will ensure grounding continuity by masking the following components prior to the painting process:

- Structure's base plate (around the anchor rod holes)
- Extension and attachments connection plates
- Air terminal plates and connection

This precise masking prevents paint from interfering with the metal-to-metal contact required for effective mechanical grounding connections.

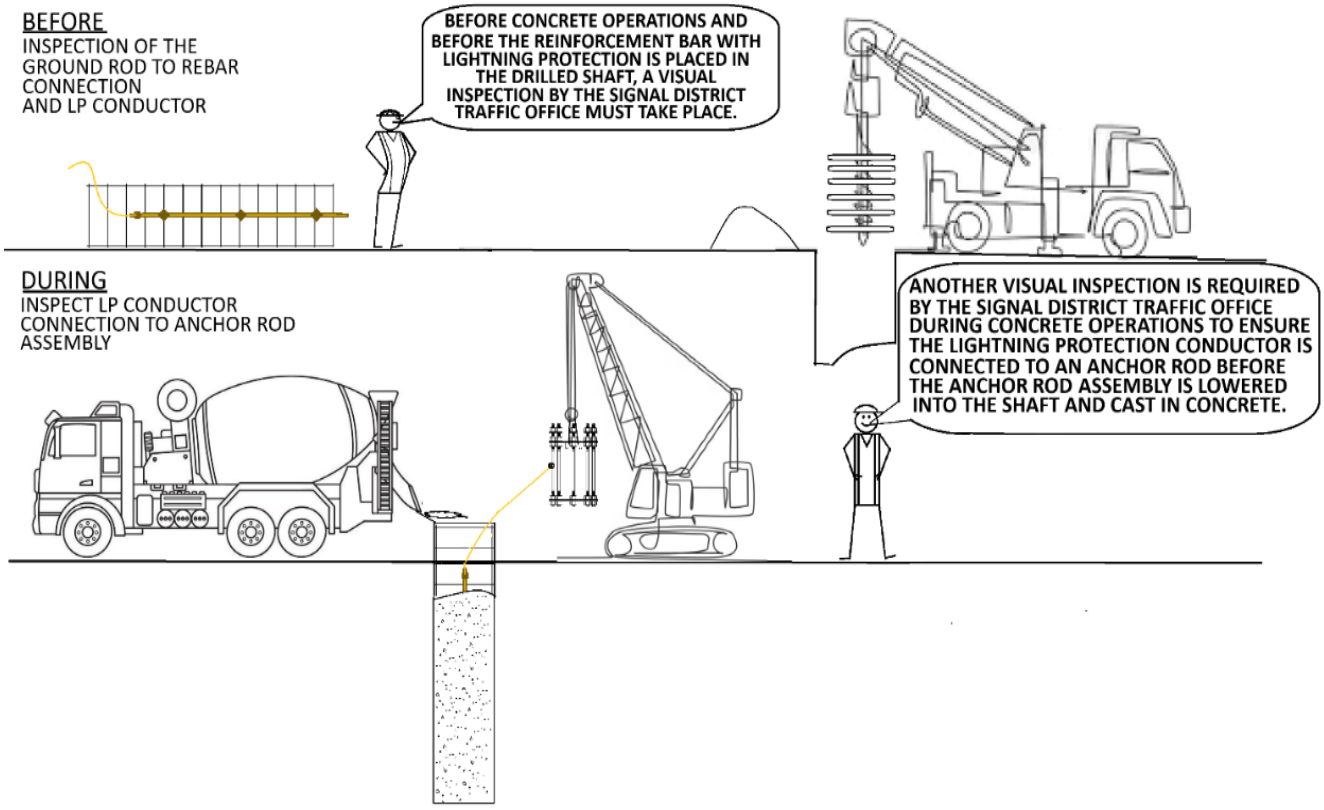
Figure 2-25 Painted Pole Masked Off Area for Grounding Continuity

2.3.8 Visual Inspection of Lightning Protection Installation

Because the lightning protection in foundations is crucial to protecting MnDOT signal equipment, a visual inspection is required by the signals district traffic office before and during concrete operations of the TS Pole foundations.

Understanding that there are constraints with people's schedules and project site travel distances, these visual inspections should be discussed between the contractor and inspector before the project begins. The inspections are direct in-person or an option for virtual inspection may be allowed if approved by the signal district traffic office. Work with your signal inspector to coordinate schedules for satisfying the required visual inspection of the LP installation.

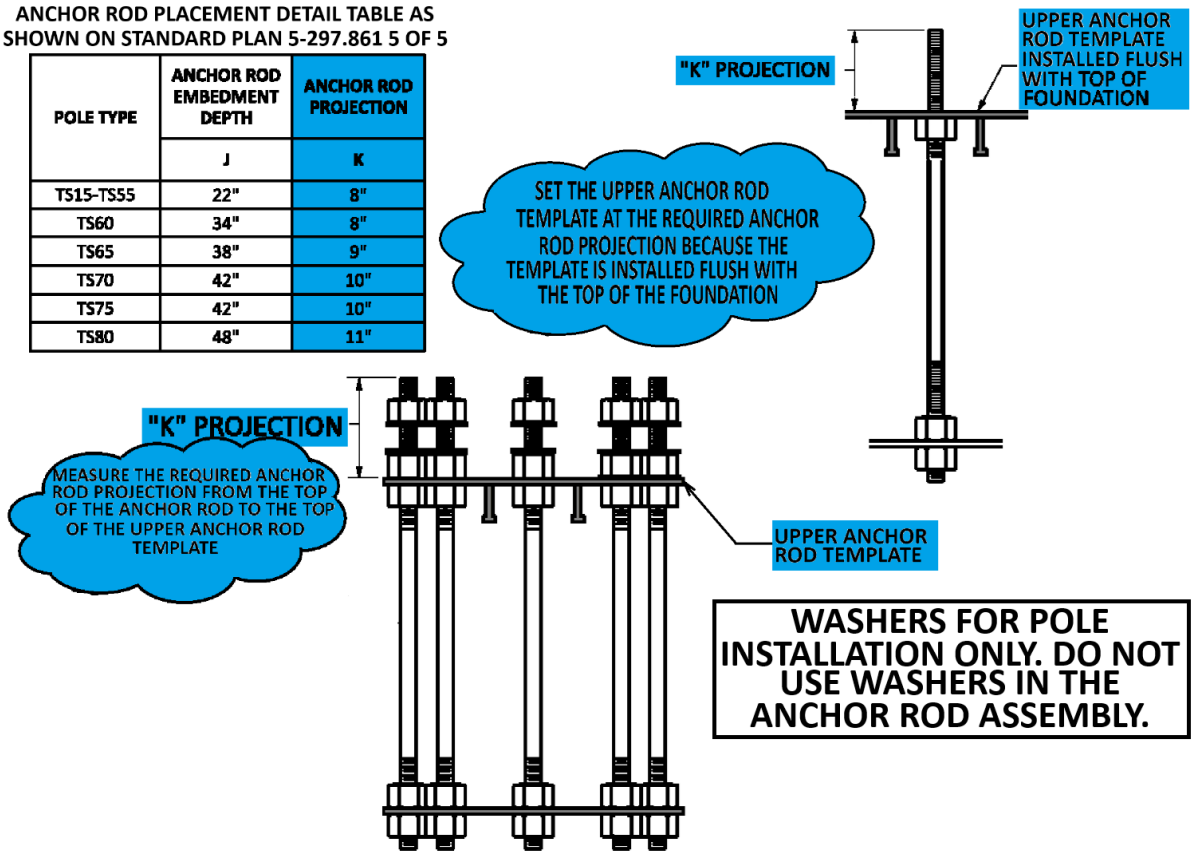
Figure 2-26 LP Installation Visual Inspection Before and During Concrete Operations



2.3.9 Anchor Rod Assembly Installation

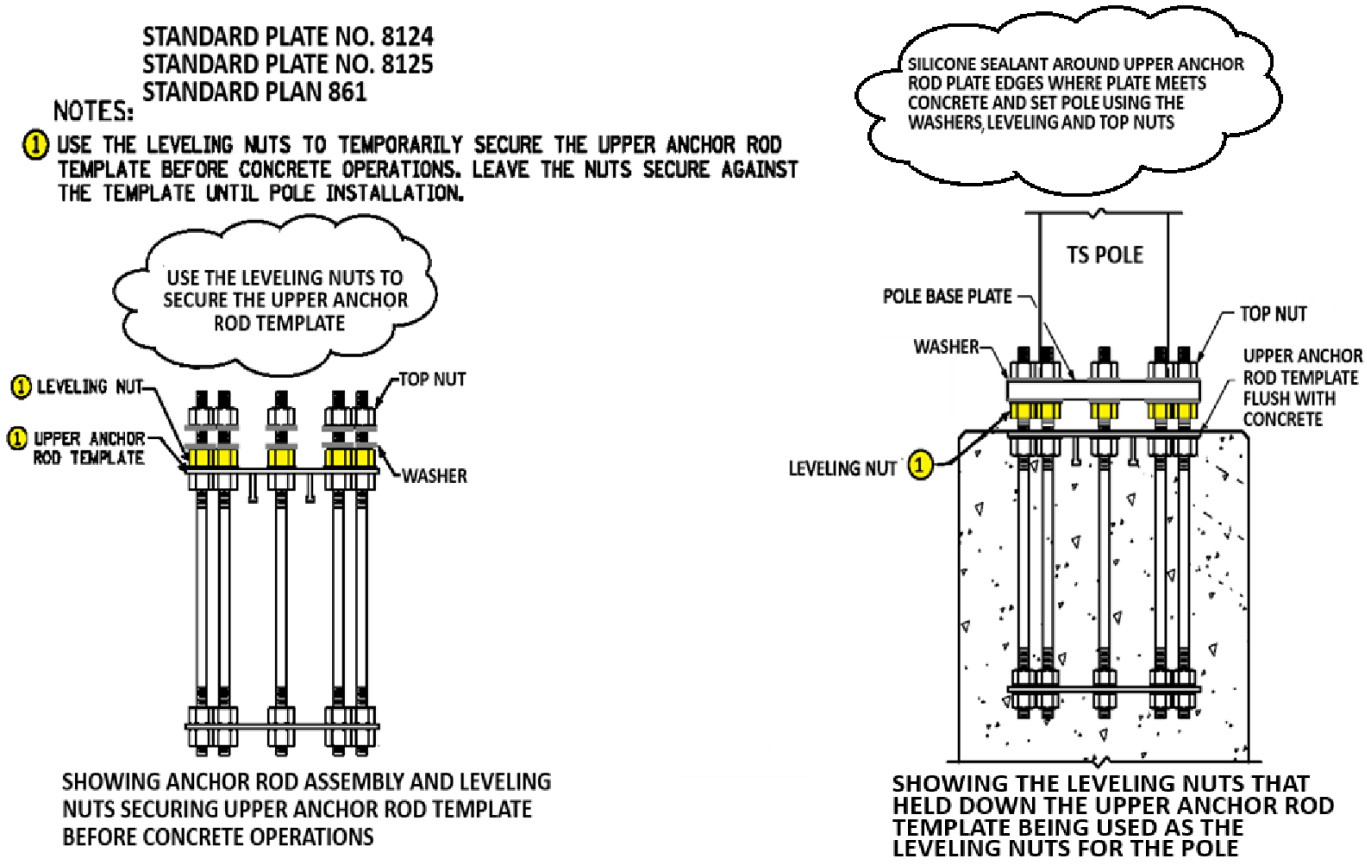
If the anchor rod assembly (anchor rods, upper and lower anchor rod plates) is assembled at the pole manufacturer's facility or shipped separately and assembled onsite, the upper anchor rod template should be set at the required anchor rod projection above the concrete foundation top in accordance with Standard Plan 861. The reason is because the upper anchor rod template is always installed flush with the top of concrete, therefore the anchor rods should be installed to the exact required projection every time. Important to note that the upper anchor rod template has the welded studs. The purpose of the welded studs is to cast in concrete to keep the plate permanently in place after the hold down nuts (pole leveling nuts) are removed.

Figure 2-27 Set Upper Anchor Rod Template to the Required Anchor Rod Projection



The nuts used to hold down the upper anchor rod template are the leveling nuts for the pole. Make sure not to use the F436 structural flat washers that are part of the anchor rod hardware between the hex nuts and the upper and lower anchor rod templates. The washers are specifically for the pole anchor rod connections.

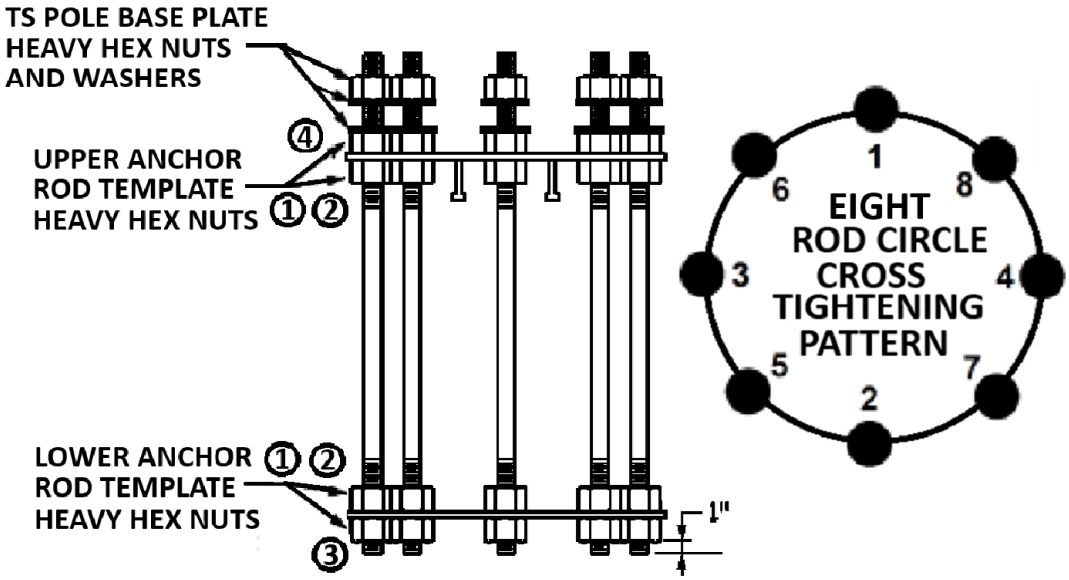
Figure 2-28 Using the Pole Leveling Nuts to Temporarily Hold Down the Upper Anchor Rod Template During Concrete Operations



If the pole manufacturer did not pre-assemble the anchor rod assemblies, follow the nut tightening process when connecting the upper and lower templates in accordance with the contract documents. Currently, nut tightening anchor rod assemblies are included in the Division SS. There is no reason to pretension (tightening with force to apply tension) the nuts and anchor rods for the upper anchor rod template. Bring upper anchor rod template nuts after hand tightening to the required condition of snug tight. Remember that the top nuts for the upper anchor rod template must be loosened to be re- used for attaching the base plate of the pole to the foundation's anchor rods.

The following figure further explains how to tighten the nuts on anchor rod template assemblies when the assemblies are not fully assembled by the pole manufacturer.

Figure 2-29 Tightening Nuts for Anchor Rod Template Assemblies



① HAND TIGHTEN EACH NUT AGAINST THE UPPER AND LOWER ANCHOR ROD TEMPLATES IN THE ASSEMBLY USING A CROSS TIGHTENING PATTERN BEFORE BRINGING TEMPLATE CONNECTIONS TO SNUG TIGHT. ENSURE THE UPPER ANCHOR ROD TEMPLATE IS PROPERLY POSTIONED AT THE CORRECT ELEVATION TO MEET THE FOUNDATION'S REQUIRED ANCHOR ROD PROJECTION HEIGHT AND BOTH UPPER AND LOWER TEMPLATES ARE LEVEL WITHIN THE ASSEMBLY.

② BRING UPPER AND LOWER ANCHOR ROD TEMPLATE CONNECTIONS TO SNUG TIGHT BY APPLYING A HANDHELD WRENCH TO EACH NUT IN A CROSS TIGHTENING PATTERN. DO NOT USE IMPACT WRENCHES, PIPE WRENCHES, OR ADJUSTABLE PLIERS.

③ AFTER SNUG TIGHT IN NOTE②,TIGHTEN THE LOWER ANCHOR ROD TEMPLATE'S LOWER NUTS TO 250 FOOT POUNDS USING A CALIBRATED TORQUE WRENCH IN A CROSS TIGHTENING PATTERN.

④ USE THE POLE'S LEVELING NUTS TO TEMPORARILY SECURE THE UPPER ANCHOR ROD TEMPLATE BEFORE CONCRETE OPERATIONS. LEAVE THE NUTS SECURE AGAINST THE TEMPLATE UNTIL POLE INSTALLATION. USE THE REQUIRED HARDWARE FOR DOUBLE-NUT ANCHOR ROD CONNECTIONS IN ACCORDANCE WITH SPEC. 2545.3.

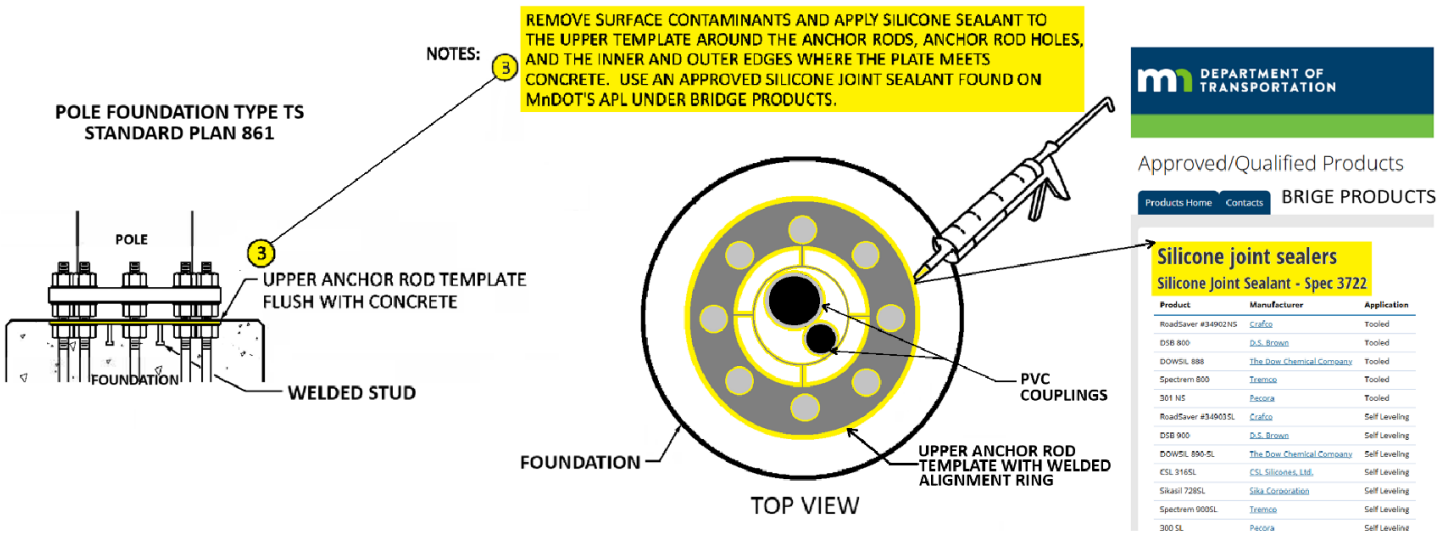
Notice the term “snug tight” is introduced into the tightening instructions for the anchor rod template assemblies. For approved torque wrenches listed on MnDOT’s APL-Signals, the “snug torque setting” on the wrench may be used for the very bottom nuts of the lower anchor rod template, however it is crucial to still apply a handheld wrench to the rest of the nuts for removing any space between the nuts and the templates.

Before casting the entire assembly in concrete, protect the anchor rod threads and the leveling nuts above the upper anchor rod template from concrete contamination, effectively preventing concrete from getting into the threads and hindering their functionality. This can be successfully done by using removable plastic caps, electrical or duct tape, or shrink wrap over the portion of anchor rod threads and nuts that will be projecting above the top of the concrete foundation and used for installing the poles.

Any time after 24 hours of concrete pouring operations but before installing the pole, clean the top (remove the containments) on and around the upper anchor rod template and apply a bead of silicone sealant listed on MnDOT’s APL-Bridge around the anchor rods, anchor rod holes, and the inner and outer edges where the plate

meets the concrete. This is to avert moisture between the steel plate and concrete joints to protect the embedded steel from corrosion and prevent the foundation top from spalling.

Figure 2-30 Apply Silicone Sealant Between the Concrete and the Upper Anchor Rod Template



2.3.10 Concrete Stamp ID for TS Foundations

Provide a custom concrete stamp tool with the following:

(1) Identification name plates that match the Foundation IDs shown on the TS Foundations Identifications Table
(2) Two- to three-inch-high letters and numbers
(3) Specifically manufactured for stamping concrete

Before the concrete dries, use a custom concrete stamp tool designated for stamping identification into concrete surfaces, stamp the top of drilled shaft and spread footing TS foundations with the corresponding identification as shown on the following table:

Figure 2-31 Foundations ID Stamp

TS FOUNDATION IDENTIFICATION		
POLE TYPE	**FOUNDATION TYPE**	**ID STAMP**
TS15-TS40	SPREAD FOOTING	40SF
TS15-TS40	DRILLED SHAFT	40DS
TS45-TS55	SPREAD FOOTING	55SF
TS45-TS55	DRILLED SHAFT	55DS

Figure 2-32 Concrete Stamp Tool for Foundation ID

Stamp the concrete in two separate areas outside of the anchor rod circle that will not be covered by the pole base plate. Ensure imprinted ID in the concrete is legible.

CHAPTER 3 TS POLE STEEL

This chapter describes all steel components of TS Pole information related to materials and construction requirements necessary for erecting a TS Pole as specified for the project. TS Pole steel includes the following:

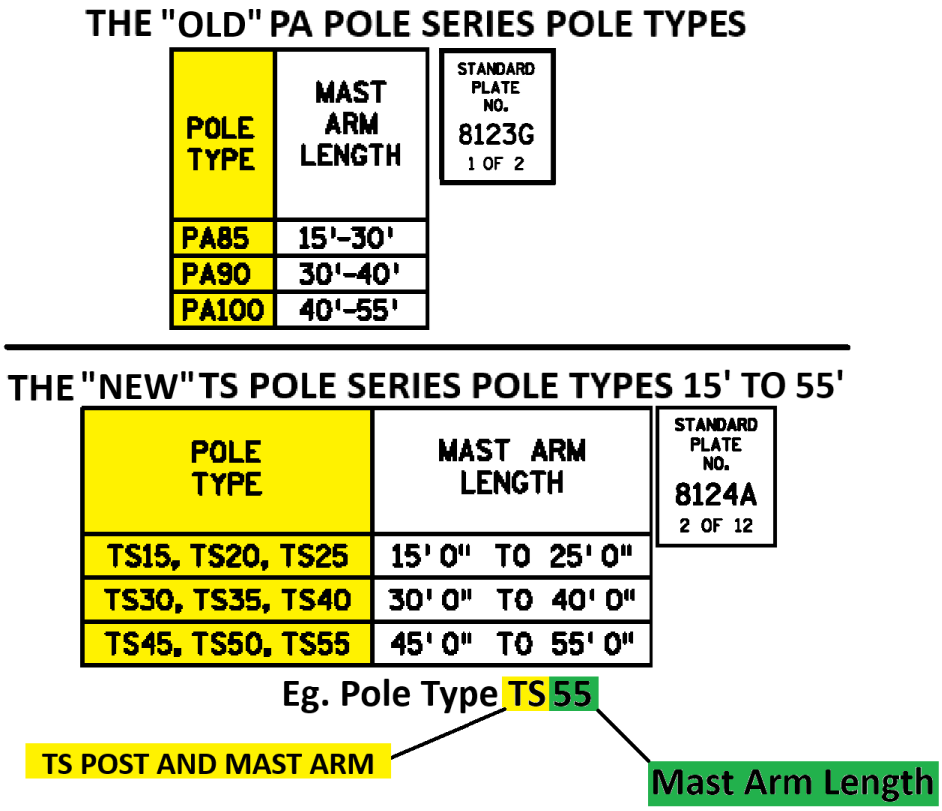
- Post (Vertical Shaft)
- Mast Arms
- Extensions and Attachments

Anchor rods, anchor rod templates, and anchor rod assemblies are considered part of the TS Pole steel since they are included with the TS poles and mast arms in Standard Plate No. 8124 and Standard Plate No. 8125 but, for this publication they have been included in Chapter 2 Foundations instead of this chapter since they are a major component of the TS Pole Foundation construction as shown in Pole Foundation Type TS Standard Plan 861.

3.1 Post and Mast Arm Type TS

The acronym "TS" used in Post and Mast Arm Type **TS** stands for "Traffic Signal". The Post and Mast Arm Type TS is commonly known as the "TS Pole" which includes the mast arm despite that it is not mentioned in the informal moniker. The TS Pole is divided into two main categories. One category is the Post and Mast Arm Type TS Mast Arm Assembly for Mast Arm Lengths 15' to 55' Standard Plate No. 8124. This pole structure replaces Pole and Mast Arm Standard Plate No. 8123 and Transformer Base and Pole Base Plate PA 85, PA 90, and PA 100 Standard Plate No. 8121, or as most people referred to it as the "PA Pole" for mast arm lengths 15' to 55'. Like how the PA Pole was then further classified into Pole Types based on the pole's T-Base and PA Pole Foundations, as some may recall pole types "PA 85", "PA 90" and "PA 100", so is the TS Pole further subdivided into Pole Types but related to the individual mast arm length the post uses.

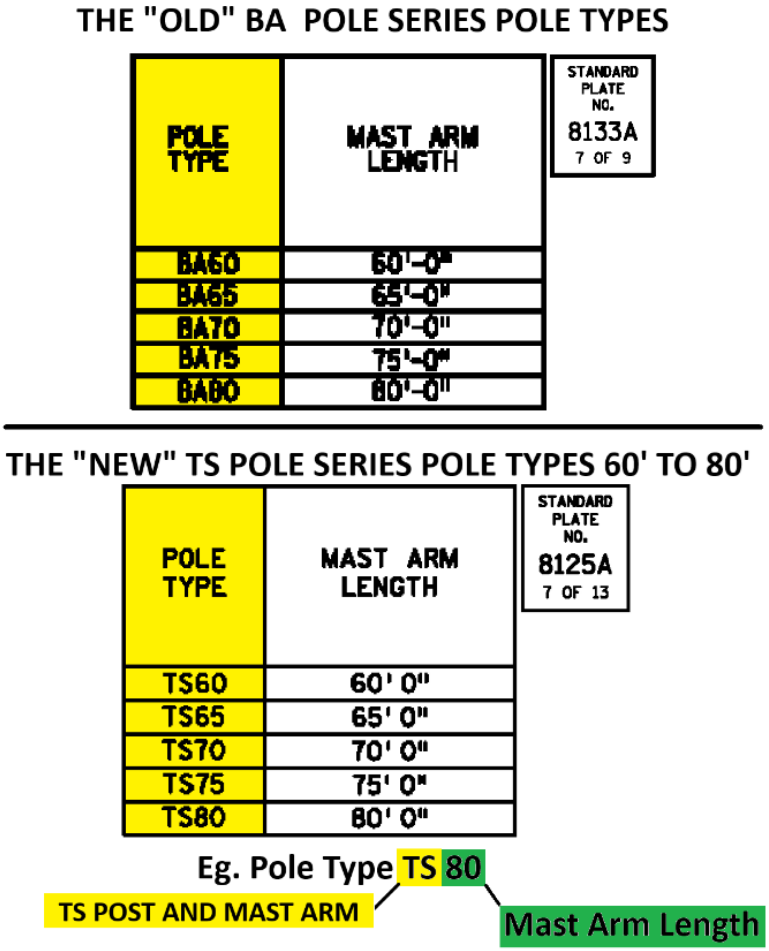
Figure 3-1 Old PA Series Pole Types and the New TS Series Pole Types 15' to 55'



The other TS Pole category is the Post and Mast Type TS Mast Arm Assembly for Mast Arm Lengths 60' to 80' Standard Plate No. 8125. Previously mentioned in Chapter 1 Introduction, Pole and Mast Arm Type BA Standard Plate No. 8133 was essentially a larger version of the new standard Post and Mast Type TS 15' to 55', as a few

had mentioned the new TS Post 15' to 55' was "a mini-BA Pole!" The BA Pole and the new TS Pole had minimal design variations. With some minor modifications to the Pole and Mast Arms Type BA, MnDOT decided to drop the BA jargon and for consistency naming convention purposes officially named it Post and Mast Arm Type TS Mast Arm Assembly for Mast Arm Lengths 60'to 80' Standard Plate No. 8125. Basically, the once called BA Pole is now referred to as TS Pole 60' to 80'.

Figure 3-2 The "Old" BA Pole Types and the "New" TS Pole Types 60' to 80'



Like the TS Pole 15’ to 55’, the TS Pole 60’ to 80’ is further subdivided into pole type dependent on the mast arm length being used. The TS Pole mast arm lengths go from 15’ to 80’ in 5’ increments. For example, TS15 means Post and Mast Arm TS with a 15’ mast arm, TS20 means Post and Mast Arm TS with a 20’ mast arm, TS30 means Post and Mast Arm TS with a 30’ mast arm, and so on all the way up to TS80.

3.1.1 TS Post

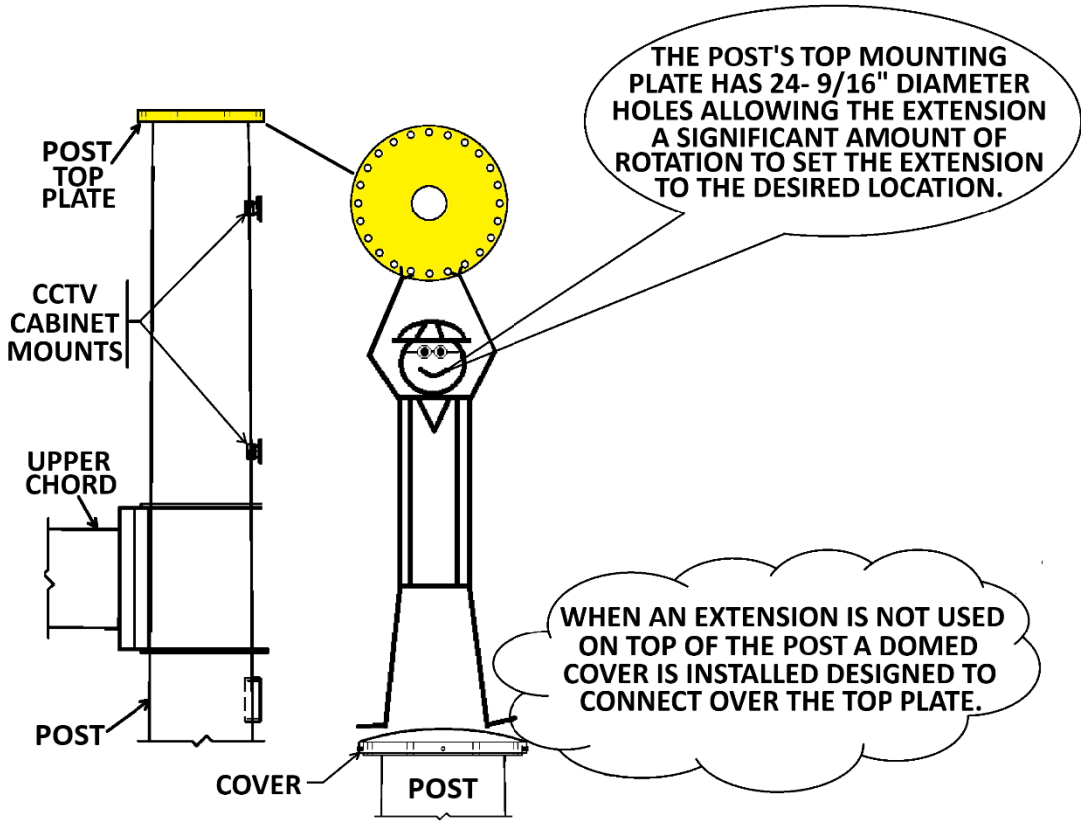
For TS posts, specifically the vertical members there will be two post types for mast arms 15’ to 55’. A post with a wall thickness of 0.250” specifically for mast arms 15’ to 40’ and a post with a wall thickness of 0.375” for mast arms 45’ to 55”. The original design included three different poles for each of the mast arm length groupings TS15 to TS25, TS30 to TS40, and TS45 to TS55. By MnDOT reducing to two pole member category types based on for mast arm lengths 15’ to 40’ and 45’ to 55’ it will make it easier and more efficient for pole fabricators, and more convenient for MnDOT ESS Stockroom for storing in the pole yard.

For TS post members employing mast arms 60’ to 80’, unfortunately there will be five different post members for each mast arm 60’ to 80’. This is because the pole types either have different anchor rod diameter sizes, different anchor rod circle patterns, different base plate diameters, or different anchor rod hole sizes in the plate making it difficult to reduce it down to fewer post members.

At the top of the TS post there is a structural mounting plate with several holes. The mounting plate is for accommodating a TS pole extension to connect when lighting and cameras are required at the intersection. The

twenty-four 9/16- inch diameter holes in the mounting plate allow the extension to be rotated and positioned at the desired location. The extension also has a mounting plate with eight 9/16-inch diameter holes designed to connect with the post member's top plate. The joining method used for connecting the plates will be eight ½ inch diameter high strength bolts.

Figure 3-3 TS Post Top Mounting Plate for Connecting Extension Shaft



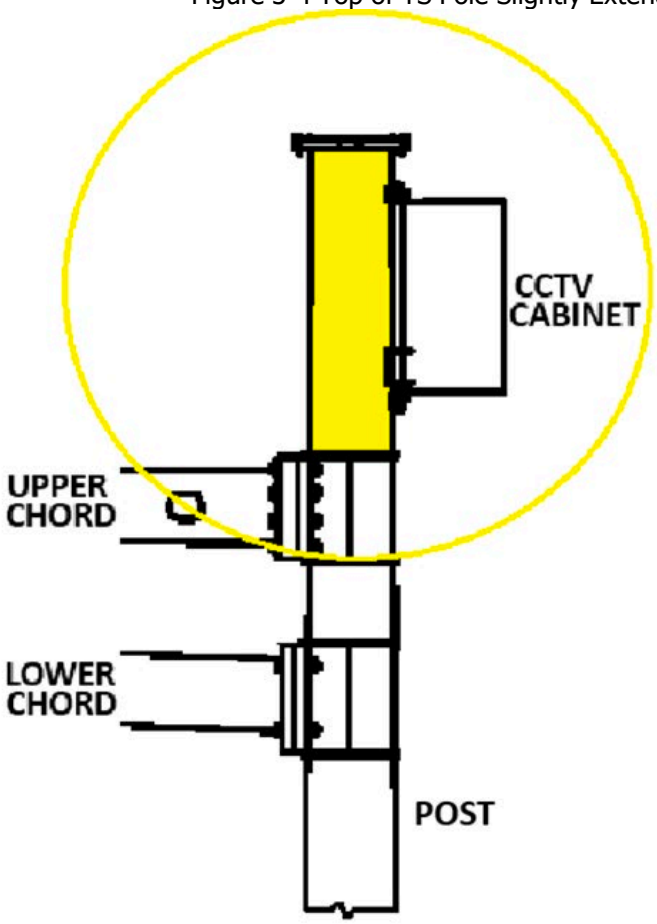
The design of the TS post top plate to provide rotation for the extension was a continuation of functionality that

the PA Series Pole rotatable extension provides. The PA Series extension connection, as some referred to as the "canned connection" allowed for that rotation. However, this unconventional "canned connection" design has been problematic for MnDOT throughout the years. The bolted connection of the TS Pole's top mounting plate to extension plate bolted is considered a standard joining method in structures as they provide a more robust and easily assembled way to connect the extension to the top of the pole rather than the unconventional joining method of the PA Series canned connection rotatable extension.

3.1.1.1 TS Vertical Pole Extended Top (CCTV Cabinet)

Some may be curious as to why the TS vertical pole member is slightly extended above the mast arm's upper (top) chord. The explanation is that the TS pole design provides some extra space at the very top portion of the pole for the purpose to mount CCTV cabinets when needed. In the original TS pole design the top of the post ended somewhere closer to the upper (top) chord of the mast arm like that of the PA series pole. However, during the designing stage of the TS pole there was a request to have a designated space on the pole specifically for mounting CCTV cabinets currently used by MnDOT RTMC. Not knowing when a cabinet would be required to be installed on a pole it made the most sense to incorporate it into the standard design of the TS pole. The TS pole is therefore designed with the extended top and welded mounting straps located on the backside of the pole where there is also a 3-inch x 5-inch access opening that will align with the opening of the CCTV cabinet as a wire way when the cabinet is mounted to the pole.

Figure 3-4 Top of TS Pole Slightly Extended to Accommodate CCTV Cabinet Installation



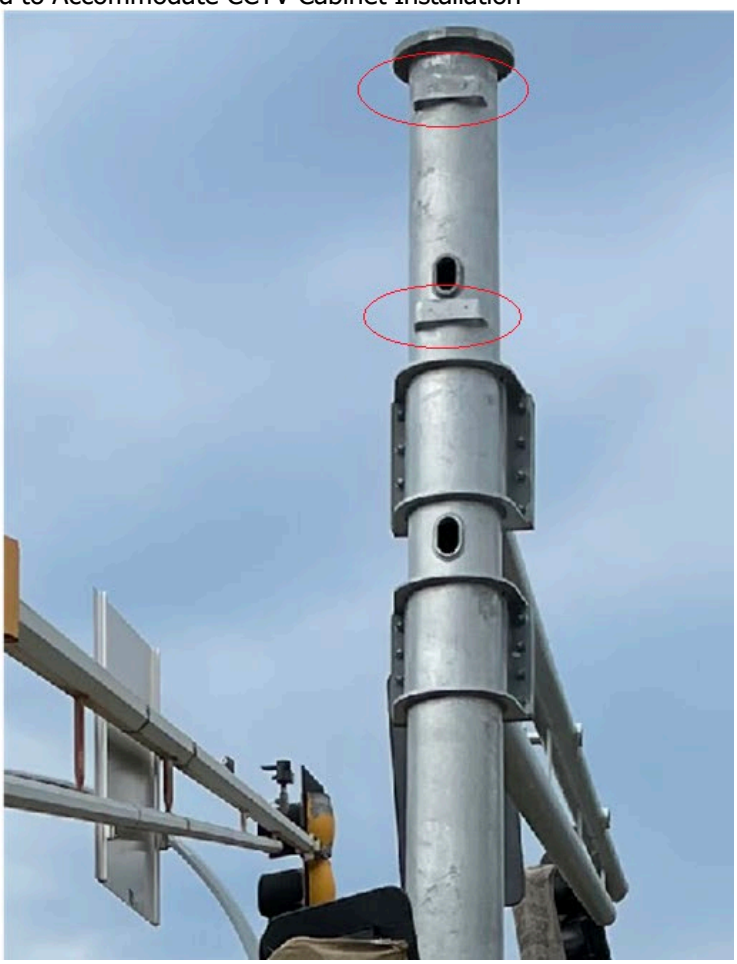
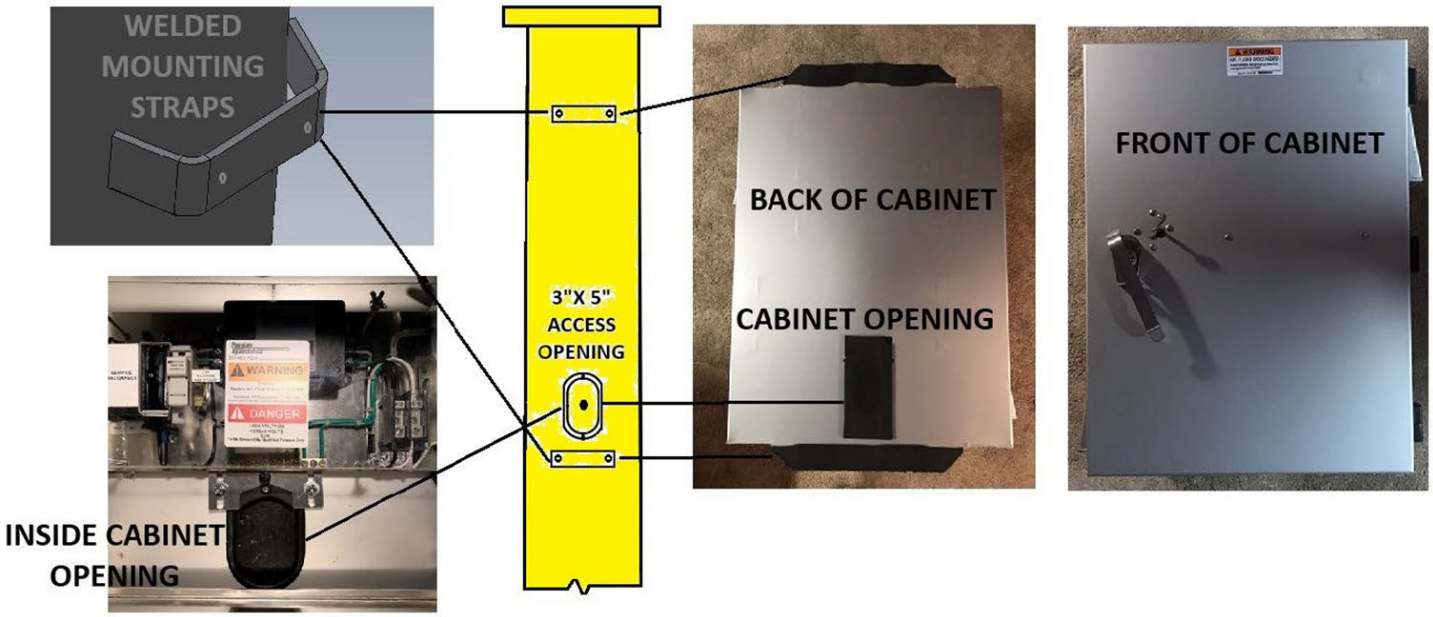


Figure 3-5 Mounting Straps on the TS Pole for Mounting the CCTV Cabinet



3.1.1.2 Access Opening and Door

To resolve clearance issues between the access opening hatch and the electric torque wrench during anchor rod tightening, the hatch will be repositioned higher on the post for future TS Pole designs to ensure proper tool access.

Figure 3-6 Electric Torque Tool and Access Opening Hatch Clearance Issue

MnDOT is currently refining the access door design for the TS Pole. Future iterations will allow the door to both swing open on hinges and be lifted off completely. Anticipate these updates in future pole designs.

Figure 3-7 First Generation Access Door Hinge

3.1.2 Mast Arms

The mast arms for TS 15-55 are considerably larger in diameter when compared to the PA series 15' to 55'. There are a couple of contributing causes for this. One, the new AASHTO LFRD design standard which includes the fatigue requirement and two, the mast arm design included wind loading of signs, since signs are typically mounted on MnDOT traffic signal mast arm structures. Both factors that were not calculated into the design of the PA Pole and Mast Arm Structure decades ago.

See the following figure to examine the differences of the TS 15-55 mast arm versus the PA series mast arm.

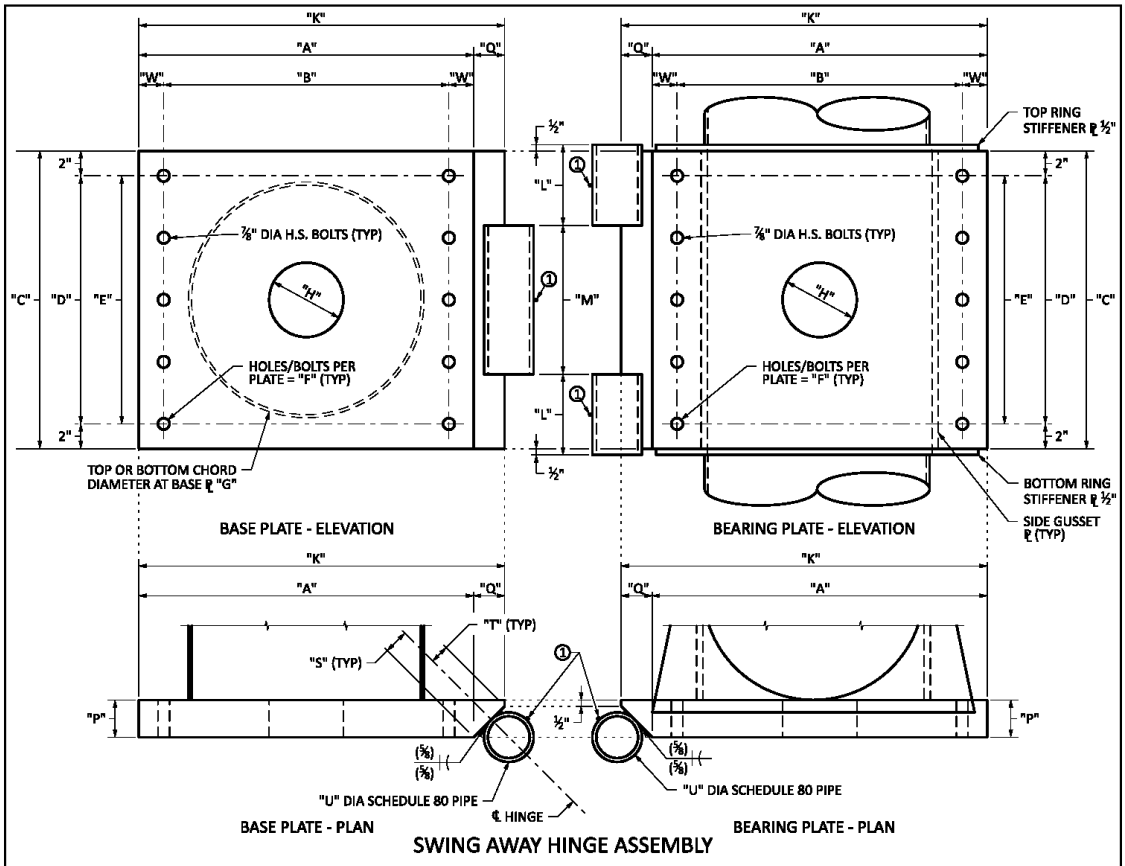
Figure 3-8 PA Series Mast Arms vs TS 15-55 Mast Arms

	Old PA Pole	New TS Pole
Description	Dimension Range for 15' to 55' Mast Arm	
Diameter of Top Chord at Base Plate	9.6" – 11.6"	8.0" – 13.2"
Diameter of Top Chord at Tip	4.0" – 5.0"	5.5"
Diameter of Bottom Chord at Base Plate	5.6"	8.0" – 12.89"
Diameter of Bottom Chord at Tip	2.8"	5.5"
Wall Thickness of Top Chord	0.120" – 0.25"	0.1875" - 0.25"
Wall Thickness of Bottom Chord	0.120"	0.1875"- 0.25"

3.1.2.1 Mast Arm Swing Away Hinge Assembly

There is a mast arm swing away hinge assembly for TS poles that is currently available as a detail. The detail will eventually become a standard plate. For signal designers that have intersections on moving routes and swing away hinges are required contact MnDOT OTE CO Signals and Lighting Unit to obtain the detail for your project.

Figure 3-9 Swing-Away Hinge Detail Drawing (Future Standard Plate)



MAST ARM	HINGE ASSEMBLY DIMENSIONS Ⓐ						
	P	Q	S	T	U	V	W
TS15-TS55	2"	1½"	1⅛"	1"	2"	1¾"	1½"
TS60-TS80	3"	2½"	2"	1½"	3½"	3¼"	2"

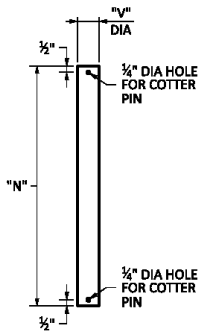
MAST ARM	UPPER CHORD DIMENSIONS Ⓑ			
	K	L	M	N
TS15-TS55	22½"	5½"	9"	22"
TS60	29½"	6½"	12"	27"
TS65	30½"	7"	13"	29"
TS70	31½"	7"	13"	29"
TS75	33½"	7½"	14"	31"
TS80	34½"	9½"	16"	37"

MAST ARM	LOWER CHORD DIMENSIONS Ⓒ			
	K	L	M	N
TS15-TS55	22½"	5½"	6"	19"
TS60	29½"	5½"	9"	22"
TS65	30½"	5½"	9"	22"
TS70	31½"	5½"	9"	22"
TS75	33½"	6½"	10"	25"
TS80	34½"	6½"	12"	27"

Ⓐ HINGE ASSEMBLY DIMENSIONS ARE SIMILAR FOR UPPER AND LOWER CHORD.

Ⓑ FOR DIMENSIONS "A" THRU "H" OF THE UPPER CHORD REFER TO STANDARD PLATE 8124 (TS15-TS55) OR 8125 (TS60-TS80) SHEET 4.

Ⓒ FOR DIMENSIONS "A" THRU "H" OF THE LOWER CHORD REFER TO STANDARD PLATE 8124 (TS15-TS55) OR 8125 (TS60-TS80) SHEET 5.



NOTES:

90 DEGREE MAXIMUM HINGE ASSEMBLY ROTATION TO PREVENT DAMAGE TO GREASE ZERKS.

HIGH-STRENGTH, LOW-ALLOY, COLUMBIUM-VANADIUM, STRUCTURAL STEEL IN ACCORDANCE WITH SPEC 3310. 50,000 PSI MINIMUM YIELD.

STRUCTURAL STEEL PIPE IN ACCORDANCE WITH MNDOT SPEC 3362, A500 GRADE B OR GREATER.

PINTLE IN ACCORDANCE WITH MNDOT SPEC 3314 TYPE II - ALLOY BAR STEEL.

GALVANIZE STEEL COMPONENTS IN ACCORDANCE WITH SPEC 3394 AFTER FABRICATION. GALVANIZE HARDWARE IN ACCORDANCE WITH SPEC 3392. PROVIDE VENT HOLES.

WELDS IN ACCORDANCE WITH THE AMERICAN WELDING SOCIETY STRUCTURAL WELDING CODE (STEEL) ANSI/AWS D1.1 (CURRENT EDITION).

FASTENERS IN ACCORDANCE WITH SPEC 3391.

FURNISH AND INSTALL WASHER ON NUT END OF BOLT. NUT IS THE TURNED ELEMENT.

APPLY AN ANTI-SEIZE AND LUBRICATING COMPOUND "BRIDGE GREASE" IN ACCORDANCE WITH SPEC 3842 BETWEEN INTERIOR SURFACES OF HINGE ASSEMBLY AND PINTLE BEFORE INSTALLATION AND AFTER INSTALLATION USING GREASE ZERKS.

① INSTALL GREASE ZERKS AT MID POINT OF UPPER, MIDDLE AND LOWER HINGE AND AT LOCATIONS SHOWN ON THE PLAN VIEW.

APPROVED: XX-XX-20XX	STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION	SPECIFICATION REFERENCE	STANDARD PLATE NO.
NOT APPROVED	POLE AND MAST ARM TYPE TS SWING-AWAY HINGE ASSEMBLY	2565	XXXXX
STATE DESIGN ENGINEER			X OF X

3.1.3 Extension and Attachments

The extension for the TS pole is a 16-foot straight shaft with bottom and top mounting plates. The bottom plate is used to attach to the top of the TS pole when lighting or cameras, or both are required at an intersection. As explained previously in the TS vertical pole member section, the post has a mounting plate with twenty-four 9/16-inch diameter holes to accommodate eight ½ inch diameter high strength bolts to connect the extension to the top of the pole. This allows for the extension to be rotated to a preferred location. The extension also has 3-inch x 5-inch access openings at the bottom near the mounting plate, another at the luminaire attachment mounts and then one more at the top mounting plate.

The single extension design essentially allows for combining different attachments without having to design several individual extensions for each possible type of situation. This also enables MnDOT to add or remove lighting or cameras at an intersection later in the future if needed. For instance, if the 16-foot extension and 9-foot luminaire attachment were initially installed, and then later it is sought after to add back lighting and a camera, then this can simply be done by adding the necessary attachments to the extension rather than having to replace what is out there with a different type of extension.

The attachments included are a 9-foot luminaire arm for standard intersection lighting and a 6-foot luminaire arm for intersection back lighting. The 9-foot luminaire arm also has ¾-inch welded hubs to provide a cable entry when mounting cameras on the arm. The luminaire arms bolt to the designated attachment mounts on the extension.

For different camera usage, there are 5 -foot camera extensions designed to mount onto the top plate of the extension. Like the extension to TS pole connection, eight ½ inch diameter high strength bolts are used to connect the plates together. From there specific camera attachments can be used for PTZ cameras or 360-degree cameras.

The extension, luminaire arms, camera attachments, and the 1 ½ inch diameter pipe camera arms for the camera attachments are listed on MnDOT's APL- Signals. The pipe arms attach to welded threaded half couplings in the camera attachments. The pipe arms have taper threads on one end and straight threads on the other. The end of the pipe with the tapered threads must be installed into the attachment's welded threaded half couplings. If the straight threaded end is installed into the attachment couplings they will not engage properly.

Figure 3-10 Extensions and Attachments

DEPARTMENT OF TRANSPORTATION

Approved/Qualified Products

Products Home | Contacts

Traffic control signals products

- Emergency vehicle preemption systems
- Loop detector and underground products
- Torque wrenches
- Pedestrian pushbuttons and mounting hardware
- Portable traffic signal
- RJ 45 Connectors for MnDOT Cat5e Cable
- Signal head mounting hardware
- Signal modems
- Signal poles and bases
- Signal service cabinets, Uninterupted Power Supplies (UPS), batteries for UPS systems
- Traffic signal paint
- Vehicle and pedestrian signal housings and indications
- Luminaire wire supports, connectors, terminal block coating, rodent intrusion barrier
- Zinc rich paint for galvanized pole repair
- Grounding and lightning protection products
- TS pole shaft extension and attachments ⇦
- Temporary equipment pads

DEPARTMENT OF TRANSPORTATION

Approved/Qualified Products

Products Home | Contacts

TS Extension and Attachments

MnDOT standard structures are unpainted. Notify the manufacturer if a painted finish is required for the project.

Extension (16 ft.)

Product	Manufacturer	Approval Date	Removal Date
Extension	Valmont Industries One Valmont Plaza Omaha, NE 68154	12/13/2024	
Extension	Millerbernd Manufacturing 622 6th St. South Winsted, MN 55395	12/13/2024	

Luminaire Arms

Product	Manufacturer	Approval Date	Removal Date
6 Ft. Luminaire Arm	Valmont Industries One Valmont Plaza Omaha, NE 68154	12/13/2024	
6 Ft. Luminaire Arm	Millerbernd Manufacturing 622 6th St. South Winsted, MN 55395	12/13/2024	
9 Ft. Luminaire Arm	Valmont Industries One Valmont Plaza Omaha, NE 68154	12/13/2024	
9 Ft. Luminaire Arm	Millerbernd Manufacturing 622 6th St. South Winsted, MN 55395	12/13/2024	

PTZ Camera Attachment (5 ft.)

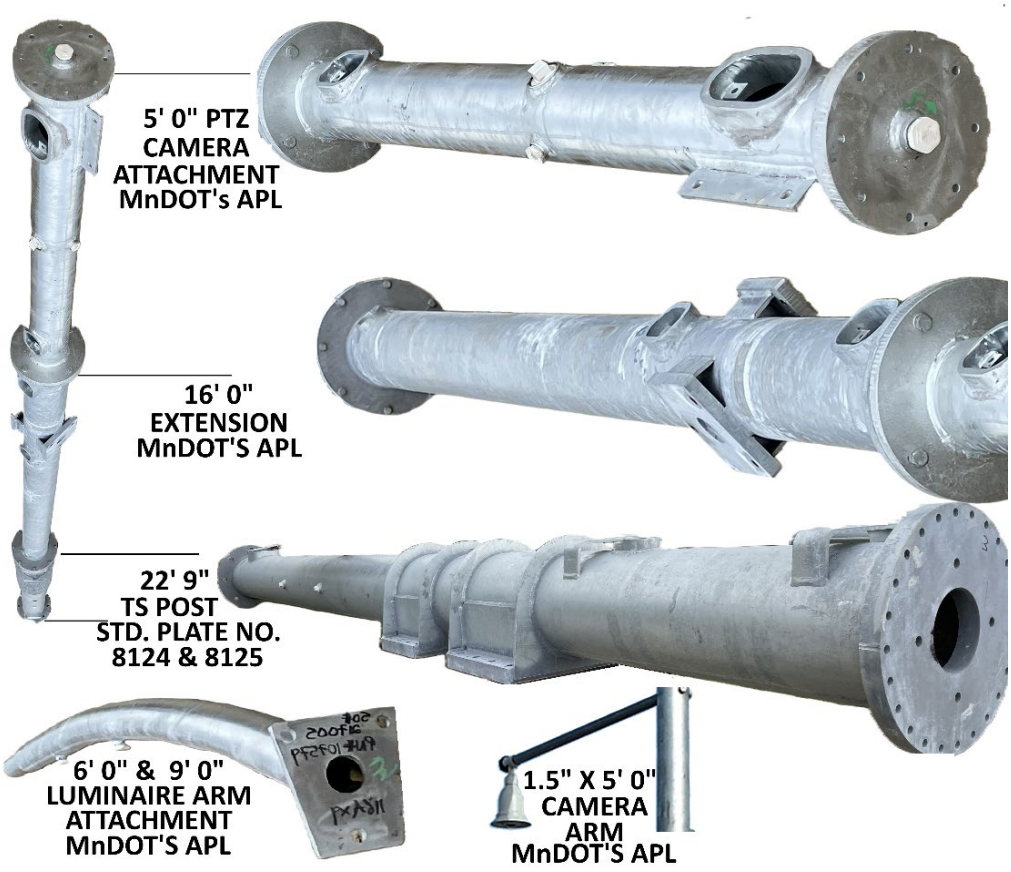
Product	Manufacturer	Approval Date	Removal Date
PTZ Camera Attachment	Valmont Industries One Valmont Plaza Omaha, NE 68154	12/13/2024	
PTZ Camera Attachment	Millerbernd Manufacturing 622 6th St. South Winsted, MN 55395	12/13/2024	

Camera Attachment (Non-PTZ) (5 ft.)

Product	Manufacturer	Approval Date	Removal Date
Camera Attachment	Valmont Industries One Valmont Plaza Omaha, NE 68154	12/13/2024	
Camera Attachment	Millerbernd Manufacturing 622 6th St. South Winsted, MN 55395	12/13/2024	

Camera Arms 1 1/2 by 5 Ft. (used with both camera attachment types)

Product	Manufacturer	Approval Date	Removal Date
Camera Attachment	Valmont Industries One Valmont Plaza Omaha, NE 68154	12/13/2024	
Camera Attachment	Millerbernd Manufacturing 622 6th St. South Winsted, MN 55395	12/13/2024	



See the following figures showing a few examples of how the extension with the attachments can be used.

Figure 3-11 Camera Attachment with Camera Arm for 360 Degree Camera on a TS Pole

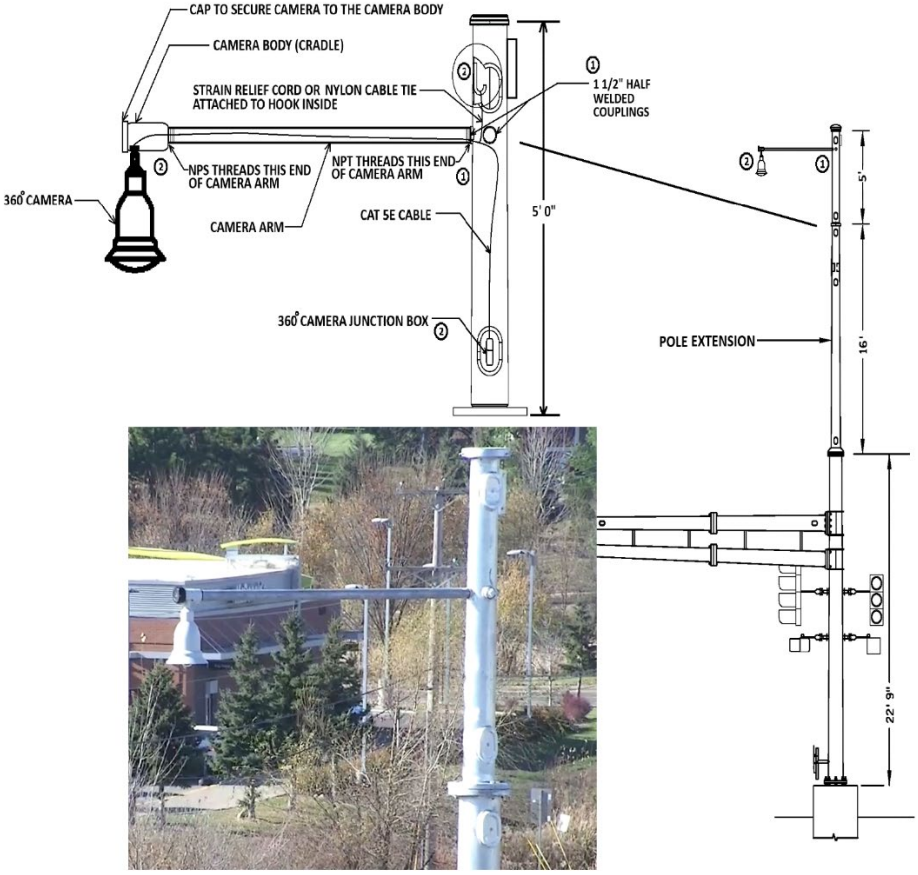


Figure 3-12 TS Pole Extension 9 ft. Luminaire Attachment with 360 Degree Camera

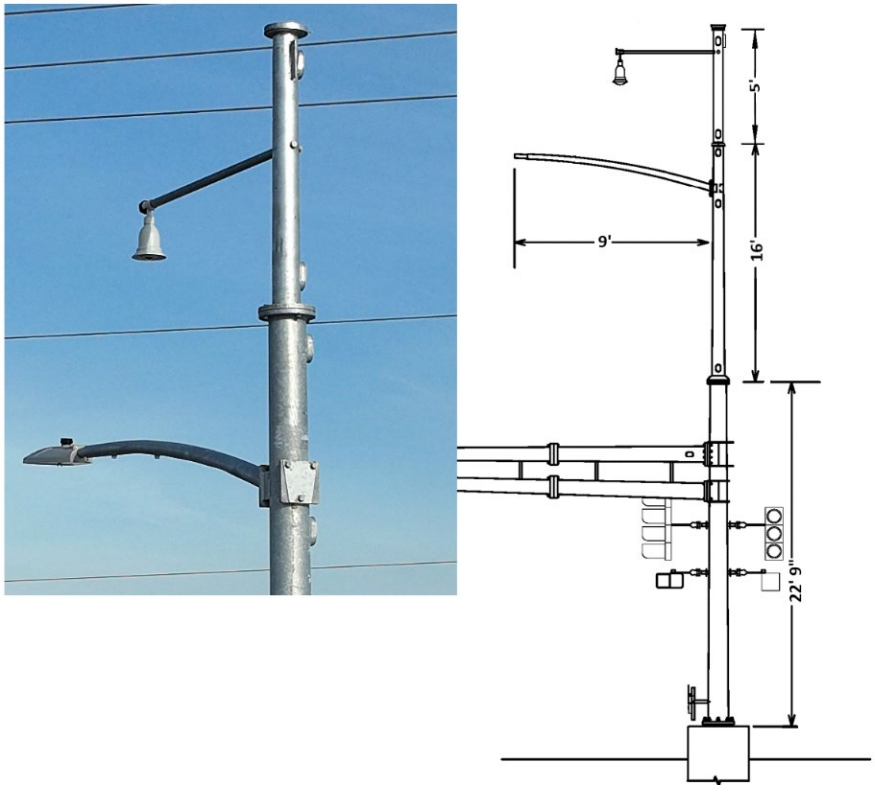
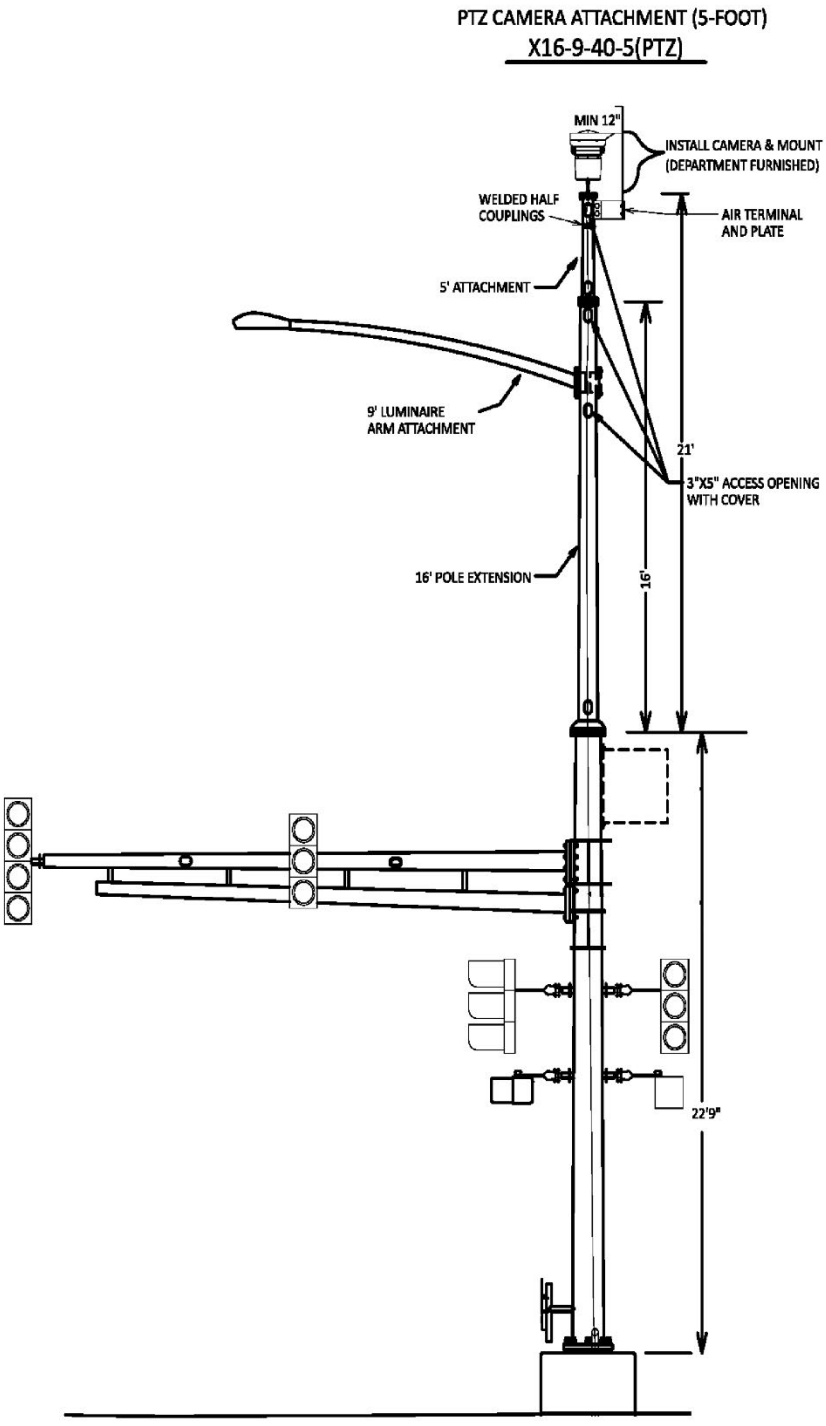


Figure 3-13 TS Pole Extension with 9 ft Luminaire Arm Attachment and PTZ Camera Attachment



CHAPTER 4 INSTALLING TS POLE STEEL

This chapter discusses storing, installing, anchor rod tightening, and high strength bolt tightening TS pole steel which includes:

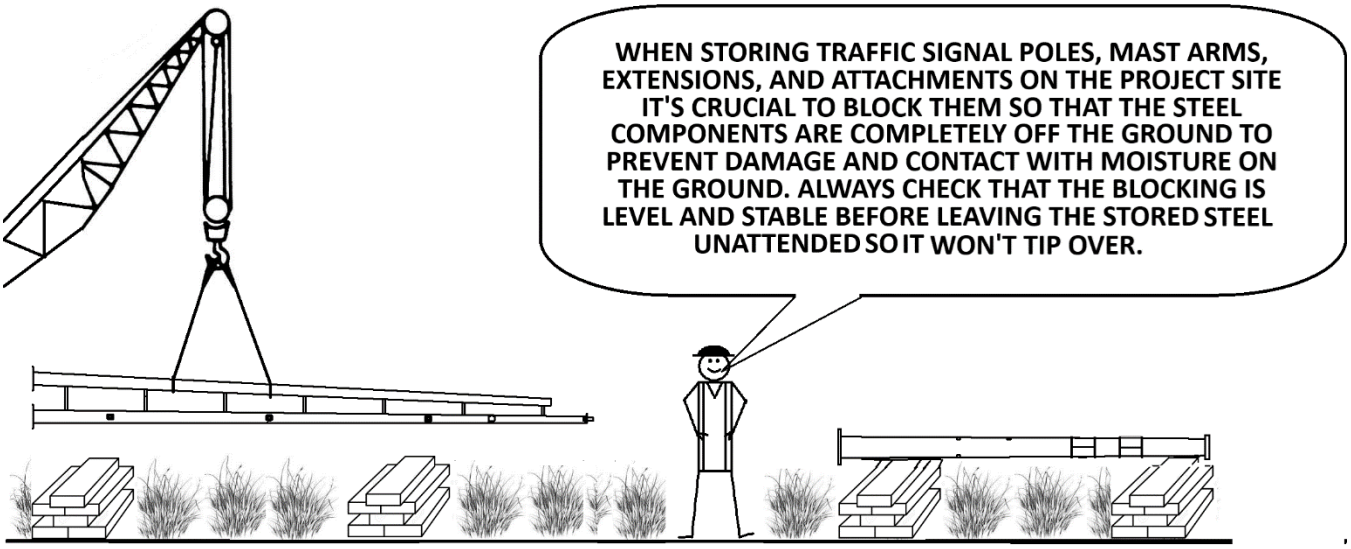
- Vertical Pole Members (Posts)
- Mast Arms
- 16 ft. Extensions

- Attachments (Non-PTZ Camera, PTZ Camera, and Luminaire Arms)

Whenever handling and lifting poles, mast arms, extensions, and attachments use natural or synthetic fiber slings and chokers or prevent the pole surface finish from coming in direct contact with metal chains and hardware when lifting to protect the galvanized or coated factory finish from mars, blemishes, or scratches. Do not drag the steel members on the ground.

Store the steel components on the project site off the ground by using blocking. Do not lay the steel directly on the ground when storing. Always check that the blocking is level and stable before leaving the stored steel unattended.

Figure 4-1 Store TS Steel Components off the Ground Using Blocking



Those who are familiar with installing PA series poles may have at some point raked the poles on the foundations by raising the leveling nuts up on the side of the mast arm. Raking the pole helps with deflection especially when the longer mast arms 45’ to 55’ are installed. The loading of the arms can cause the structure to

deflect noticeably. Once the pole is raked and the mast arm is installed the pole structure will appear plumb.

With TS poles there is no reason to rake the poles. This is because camber will be built into the mast arms to take up the deflection in TS poles. Further reason is the leveling nuts, and base plate should always be level before tightening the anchor rods. Raking could have an adverse effect on anchor rod tightening. The inability of one or more anchor rods that are not properly tightened to effectively carry loads applied to the structure results in a redistribution of anchor rod forces causing the anchor rod connections to loosen over time.

Figure 4-2 "Raking" PA Series Poles

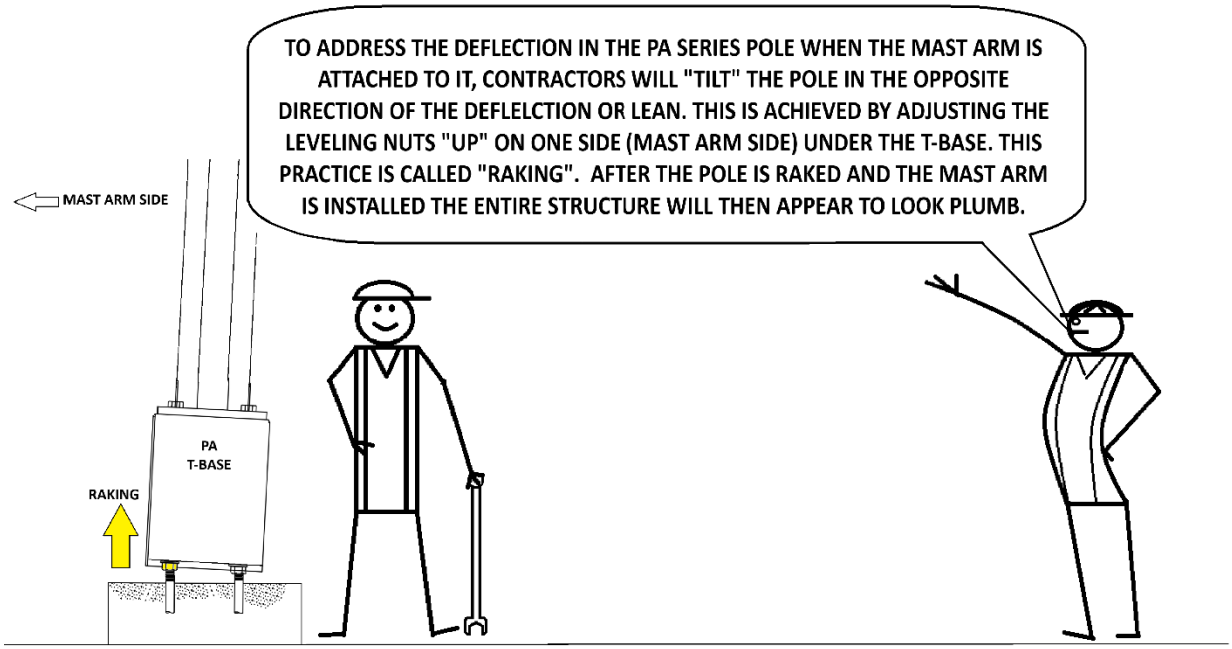
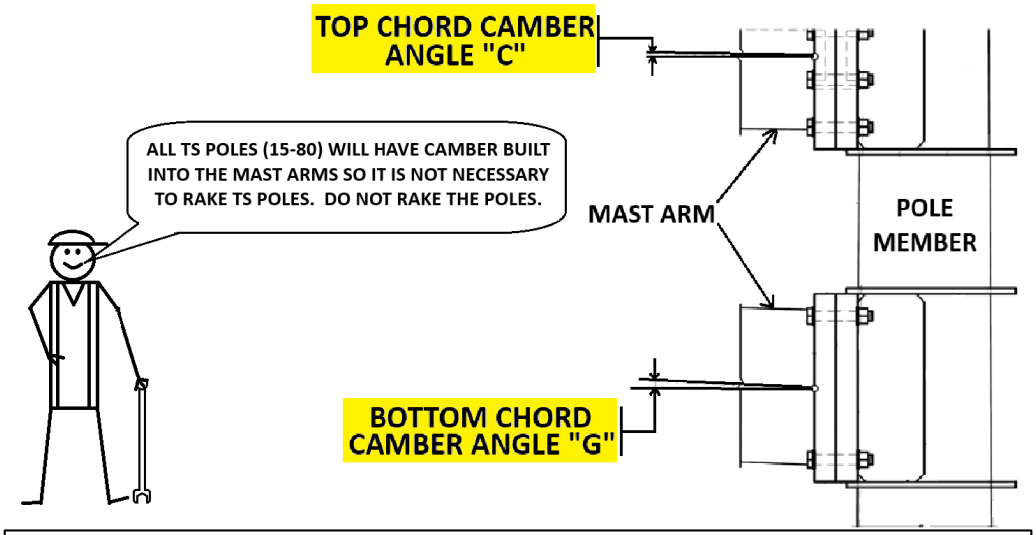


Figure 4-3 TS Pole Have Mast Arms with Built-In Camber



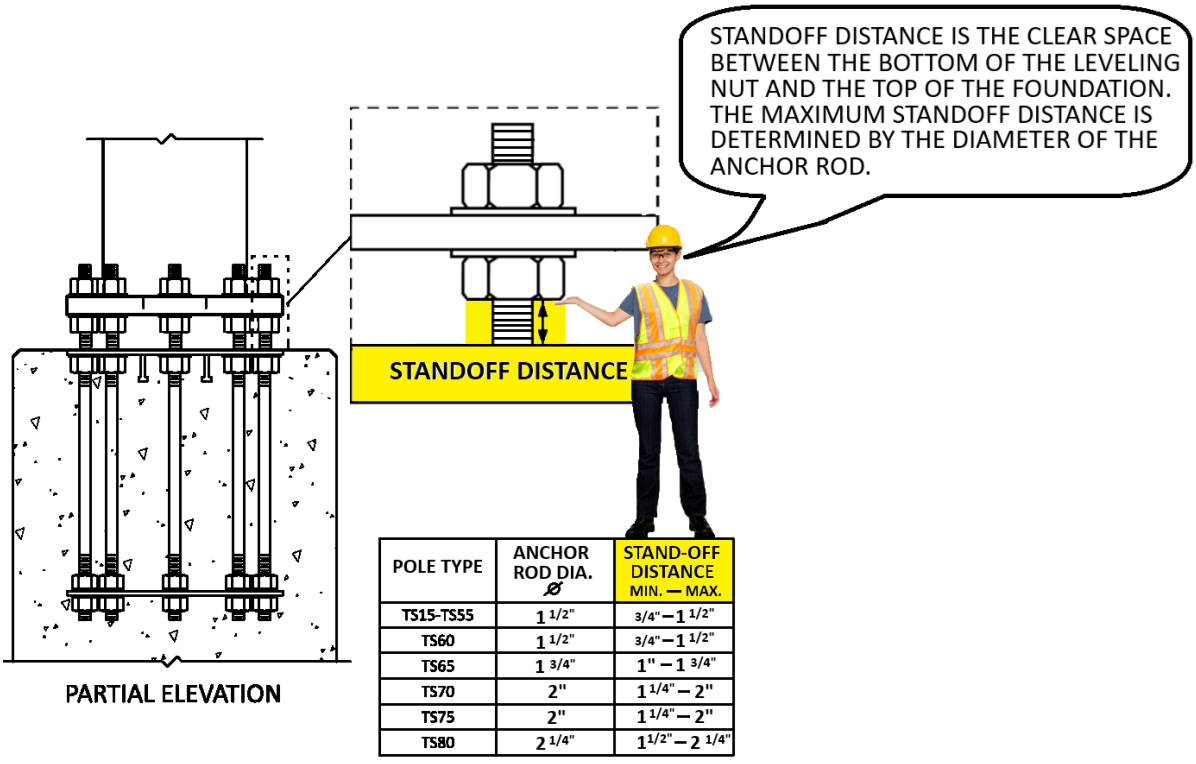
MAST ARM CONNECTION DIMENSIONS

DESCRIPTION	DIMENSION	MAST ARM LENGTH 15'	20'	25'	30'	35'	40'	45'	50'	55'
CHORD DIAMETER AT BASE PLATE	A	8.0"	8.3"	9.0"	9.7"	10.4"	11.1"	11.8"	12.5"	13.2"
CHORD WALL THICKNESS AT BASE PLATE	B	0.1875"	0.1875"	0.1875"	0.1875"	0.1875"	0.1875"	1°45'	1°45'	1°45'
CHORD CAMBER ANGLE	C	0°15'00.0"	0°15'00.0"	0°15'00.0"	0°30'00.0"	0°30'00.0"	0°30'00.0"			
RING STIFFENER SPACING - TOP	D	14"	14"	14"	20"	20"	20"	20"	20"	20"
CHORD DIAMETER AT BASE PLATE	E	8.0"	8.0"	8.69"	9.39"	10.09"	10.79"	11.49"	12.19"	12.89"
CHORD WALL THICKNESS AT BASE PLATE	F	0.1875"	0.1875"	0.1875"	0.1875"	0.1875"	0.1875"	3°15'	3°15'	3°15'
CHORD CAMBER ANGLE	G	4°00'00.0"	4°00'00.0"	4°00'00.0"	2°45'00.0"	2°45'00.0"	2°45'00.0"			
RING STIFFENER SPACING - BOTTOM	H	14"	14"	14"	14"	14"	14"	14"	14"	14"
DIAMETER OF CABLE GUIDE	J	3"	3"	3"	4"	4"	4"	4"	4"	4"

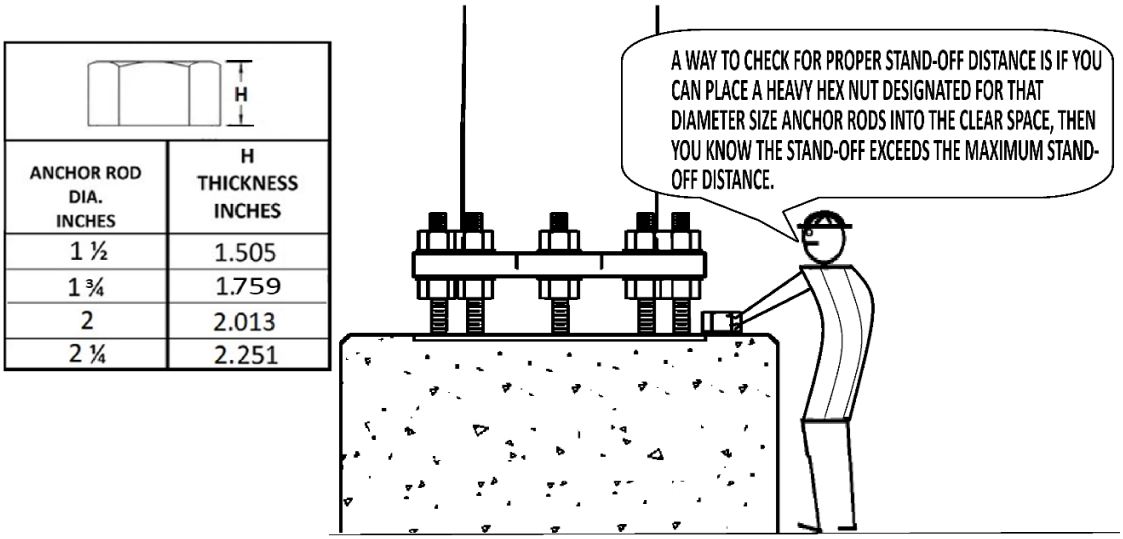
4.1 Setting Leveling Nuts

Before setting the TS pole's post on the foundation, the leveling nuts must be adjusted to the correct elevation or "stand-off distance". MnDOT Signal and Lighting Unit's definition of "stand-off distance" is the clear space between the bottom of the level nut and the top of the foundation. Setting leveling nuts too low on the anchor rods is problematic because the resulting excessive "stick-up" (too much anchor rod protruding above the base plate) prevents the wrench's socket from fully engaging the top nuts. Conversely, positioning the leveling nuts too high can cause bending stresses on the anchor rods and many not allow for full thread engagement of the top nuts.

Figure 4-4 Setting leveling Nuts to Meet Standoff Distances



POLE TYPE	ANCHOR ROD DIA. Ø	STAND-OFF DISTANCE MIN. — MAX.
TS15-TS55	1 1/2"	3/4" – 1 1/2"
TS60	1 1/2"	3/4" – 1 1/2"
TS65	1 3/4"	1" – 1 3/4"
TS70	2"	1 1/4" – 2"
TS75	2"	1 1/4" – 2"
TS80	2 1/4"	1 1/2" – 2 1/4"



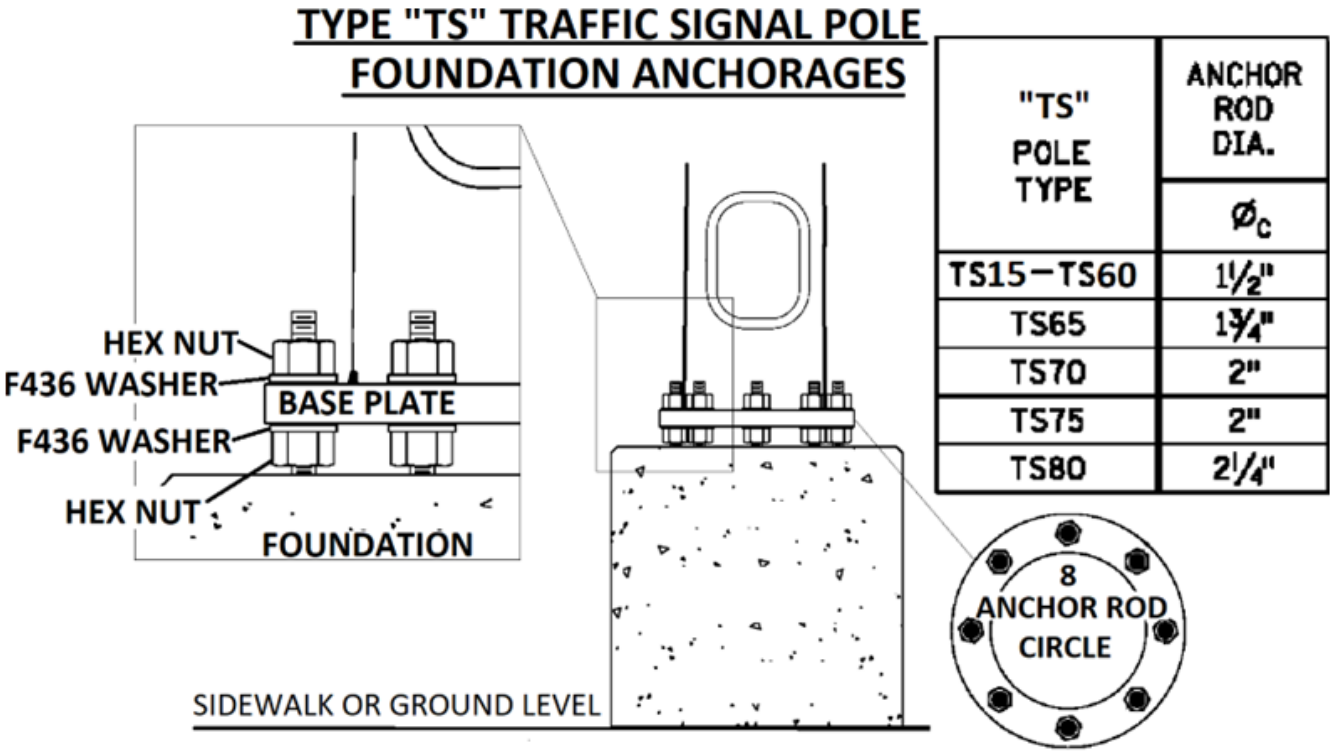
ANCHOR ROD DIA. INCHES	H THICKNESS INCHES
1 ½	1.505
1 ¾	1.759
2	2.013
2 ¼	2.251

CHAPTER 5 ANCHOR ROD TIGHTENING

For TS series poles, anchor rod tightening should be relatively straight forward. The pole anchor rod connections are exposed on the outside of the pole and at least 2'-3" above ground level because of the foundation projection which allows a person to stand while performing the anchor rod tightening steps. A significantly better situation than trying to access and tighten anchor rod nuts that are 6 inches above ground level and inside of a transformer base like that of the PA series poles. What's more is, even though there are eight rods as opposed to the four PA series pole rods, the TS15 to TS60 softer Type B Grade 55 1 ½ inch diameter rods make it easier to achieve the maximum required torque value of 700-foot pounds instead of the 3,150-foot pounds required for the PA Pole's 2-inch diameter Type C Grade 105 anchor rods.

The anchor rod connections order of hardware for TS series poles is the same as the PA series. The anchor rod connections are a double nut connection starting from bottom up it consists of a leveling (or bottom) heavy hex nut, a hardened structural F436 flat washer, then the base plate, followed by another hardened structural F436 flat washer and heavy hex nut on top. The following figure shows the anchor rod connections order of hardware for the TS poles. MnDOT does not use lock washers in structural pole to anchor rod connections. Lock washers can break and cause the anchor rod connection to loosen over time. Based on anchor tightening research, if the anchor rods are properly tightened as required, anchor rod connections should never come loose.

Figure 5-1 Order of Hardware for TS Pole Anchor Rod Connections



"TS" POLE TYPE	ANCHOR ROD DIA. $\varnothing_C$
TS15–TS60	1½"
TS65	1¾"
TS70	2"
TS75	2"
TS80	2¼"

5.1 TS Pole Anchor Rod Torque Controlled Tightening Method

MnDOT requires TS pole anchor rods to be tightened using the torque-controlled tightening (TCT) method. This tightening method ensures the anchor rods are tightened to the correct tension, preventing issues like

overtightening (which can cause damage anchor rods) or under-tightening (which can result in anchor rods loosening over time). How it works is the required torque is assigned based on anchor rod diameter, and anchor

rod type and grade. An approved cordless torque wrench is adjusted to the required torque value. And then the torque wrench is used to tighten the anchor rod nuts by rotationally applying force. Once the required torque value is reached, the wrench will indicate this by using a mechanical stop telling the wrench operator that the specified torque has been met.

The advantages using the TCT method:

- **Reduces Human Error:** Helps minimize the risk of over-tightening or under-tightening, which can lead to damage or failure.
- **Ease of implementation:** Easy to use and understand tightening method by simply providing torque values compared to other methods such as turn of the nut or angle-controlled tightening.
- **Consistency:** Ensures the anchor rod connections are tightened to the same level of clamping force each time, improving reliability and predictability.

The disadvantages using the TCT method:

- **Friction Sensitivity and Requires Lubrication:** Lubricant must be used since the torque wrench cannot tell the difference between torque and tension.
- **Torque wrenches Require Regular Calibration:** Calibrated torque wrenches are necessary to provide accurate torque as specified when tightening anchor rods to ensure proper tightening.
- **Leveling Nuts Required to be Snugged:** All leveling (bottom) nuts with the bottom F436 washers are required to be snugged before tightening the top nuts to ensure each anchor rod connection has clamped the baseplate.

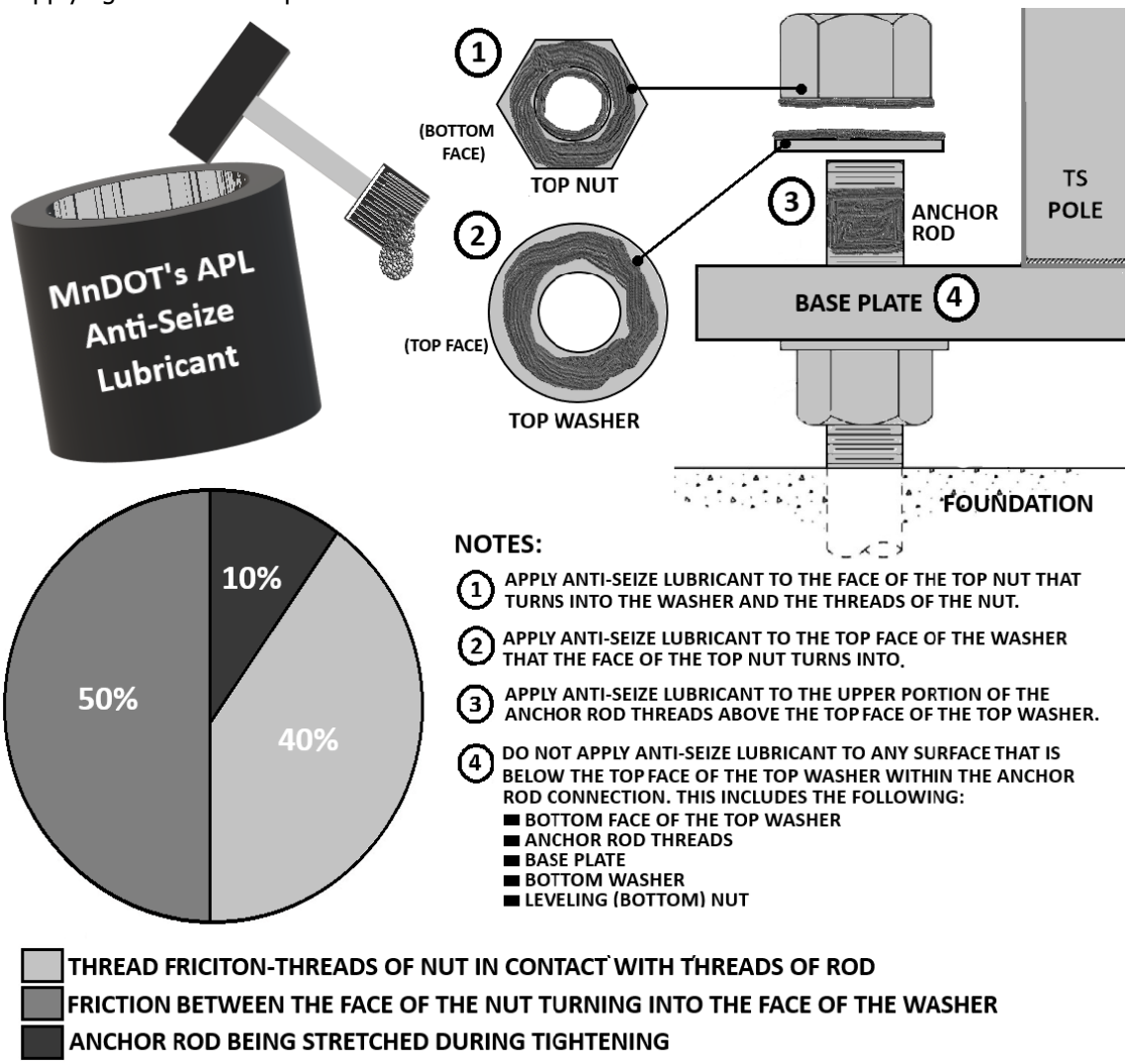
All the required steps for TS Pole anchor rod tightening are necessary and should not be skipped to effectively resist self-loosening of anchor rods. It is also apparent, just based on the noted disadvantages of using TCT method, anchor rods will loosen over time if any one of following steps listed is ignored:

- **Apply lubricant when directed in the installation procedures and not before then. Why?** Apply anti-seize **AFTER** setting the pole (post) on the foundation anchor rods and not before to prevent dirt buildup in the lubricant and contamination on connection surfaces that shouldn't have it.

Figure 5-2 Wrong Time to Apply Anti-Seize Lubricant/ Apply **AFTER** Setting the Pole

- **Use an approved lubricant to the specified areas. Why?** It is crucial for removing certain surface conditions and rust that creates friction within the anchor rod connection since torque wrenches cannot distinguish between the tension in the anchor rod and the friction encountered (shown on Figure 5-2) when applying the required torque values during the anchor rod tightening process. This could lead to inaccuracies achieving the desired anchor tension.
  DO NOT apply any lubricant below the topside (top face) of the top F436 structural flat washer. This is to make sure the base plate does not slide in the double nut clamped connection. Apply lubricant only to the areas specified on Figure 5-2.

Figure 5-3 Applying Lubricant to Specified Areas of the Anchor Rod Connection

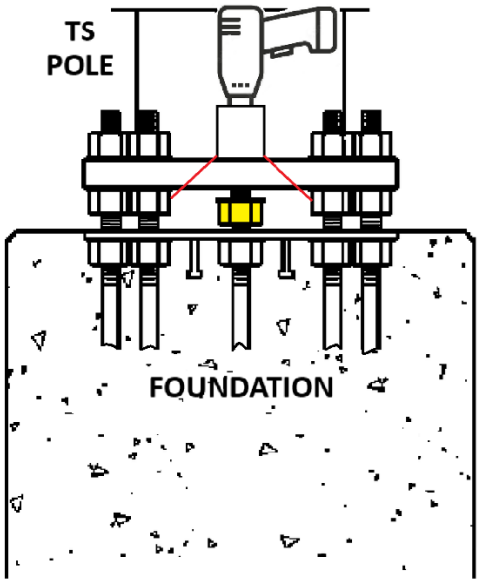


- **Use calibrated torque wrenches. Why?** Calibrated torque wrenches are crucial for ensuring precise torque when anchor rod tightening as it verifies the wrench's accuracy and reliability that each anchor rod connection has been equally tightened to the specific amount of required torque every time. And it confirms that each anchor rod connection carries an equal amount of the correct load, preventing both overtightening and under tightening, which can lead to damage or failure of the structure.

- **Snug All Leveling Nuts. Why?** A specified torque value as required must be applied to all the leveling (bottom) nuts using a crows-foot type torque wrench or a click type torque wrench with a crows-foot attachment after snugging the tops nuts but before torque tightening the top nuts. Snugging the leveling nuts to the specified torque value after snugging the top nuts will remove any space between the nut, the washer and the baseplate. This guarantees all the anchor rod connections have clamped the baseplate with washers between the top nut and the bottom. Failure to complete this step could potentially lead to an anchor rod connection not clamping the baseplate. Any anchor rod connection not clamping the baseplate will result in the other anchor rods picking up the tension in the baseplate as shown in Figure 5-3 since the double nut anchor rod connection very little clamp load, and therefore not equally distributing any load applied to the pole into each of the anchor rods. As a result, the rest of the anchor rod connections will come loose over time.
  Do NOT use lubricant on the leveling nuts, bottom washers, and anchor rod threads for snugging. Why? As mentioned earlier and as shown in Figure 5-2, never apply lubricant below the top face of the top washer. Keep in mind, the leveling nuts are only being snugged to a specific torque value that has been evaluated to get past any friction within the anchor rod connection below the base plate. This specified torque value should be enough to snug the leveling nut and remove any space between the leveling nut and the bottom of the base plate and for the anchor rod connection to clamp the base plate.

Figure 5-4 Space Between the Base Plate and Leveling Nut

ANY SPACE OR GAPS BETWEEN THE BOTTOM OF THE BASE PLATE, LEVELING NUTS AND BOTTOM WASHERS WILL NOT PROVIDE A CLAMP ON THE BASE PLATE BETWEEN THE TOP NUT AND THE BOTTOM NUT AFTER FINAL TIGHTENING. THE TENSION WHEN THE TOP NUT IS TIGHTENED WILL RELOCATE INTO THE OTHER ANCHOR RODS AND CREATE AN UNEVEN DISTRIBUTION BETWEEN ALL THE ANCHOR RODS WITHIN THE POLE TO FOUNDATION CONNECTION. OVER TIME THE REST OF THE ANCHOR ROD CONNECTIONS WILL LOOSEN.



USE A CLICK TYPE TORQUE WRENCH WITH A CROWS FOOT TO SNUG THE LEVELING NUTS TO THE SPECIFIED TORQUE VALUE

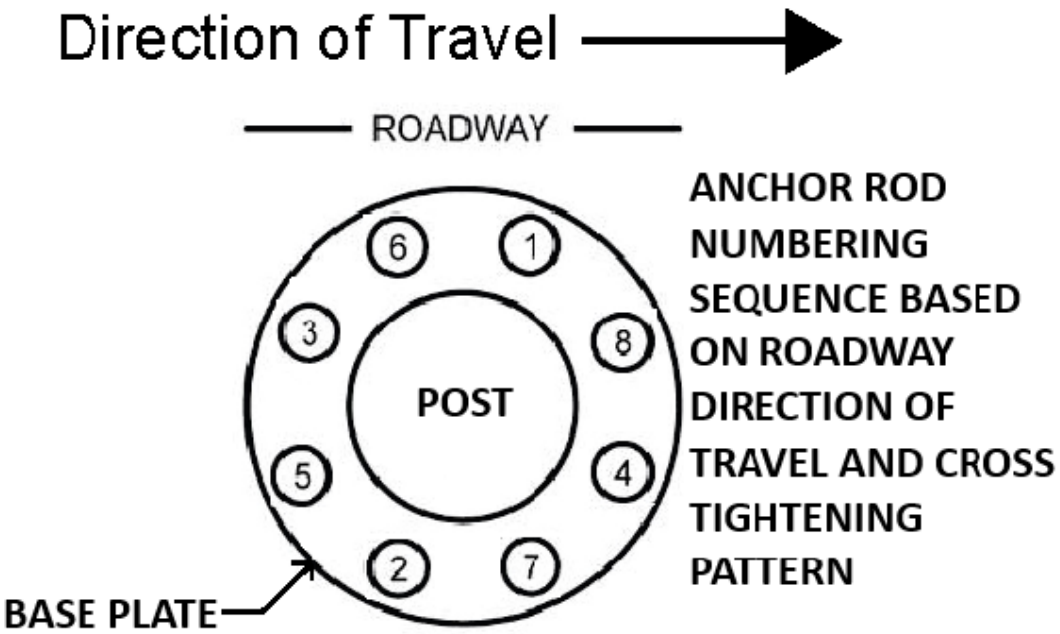
5.2 Standard Anchor Rod Numbering Convention and Sequence

This section outlines the general orientation and numbering convention to use for anchor rod tightening. When performing anchor rod tightening and for structural inspections it is important to identify the orientation of the

anchor rods on each base plate for consistency between poles. Each pole's base plate should be numbered in the same direction.

MnDOT's Signals and Lighting required practice is to number the top of the anchor rods using the primary direction of travel as a reference point and in conjunction with the required cross-tightening pattern for anchor rod tightening as shown in Figure 5-4.

Figure 5-5 Anchor Rod Numbering Methodology



5.2.1 Cross Tightening Pattern

Whether snugging or tightening top nuts and leveling nuts in any of the required anchor rod tightening steps always use the required cross tightening pattern since it is crucial for achieving a uniform and reliable connection. Cross tightening pattern helps distribute the load evenly across all the anchor rods, providing a more stable connection that is less prone to vibrations or loosening over time.

5.3 Cordless Battery Torque Wrenches for TS Pole Anchor Rod and Bolt Tightening

MnDOT requires cordless battery gun torque wrenches listed on MnDOT APL-Signals to be used for TS pole anchor rod and bolt tightening. The approved cordless torque wrenches listed on MnDOT's APL specifically are modified for MnDOT use by the wrench manufacturer. These wrenches have the Bluetooth technology capable of sending out recorded torque data to an external device through wireless connection, essentially enabling real-time torque data transmission to signal inspectors or the information can be saved on an electronic file and submitted to the signal inspector ensuring that the torque values have been met for pole anchor rods and bolts. This digital technology eliminates the need for tightening to take place in the presence of an inspector and having to fill out the anchor rod tightening forms. Refer to the project's special provisions and work with the district traffic signal inspector on the project before tightening anchor rods and bolts to determine how the information should be submitted to the project engineer.

Figure 5-6 Cordless Battery Torque Wrench Tightening TS Pole Anchor Rods

The cordless battery torque wrenches have a "rundown" feature, or snug setting. Because of this, the 20% torque value cycle for typically tightening anchor rods and bolts has been eliminated for tightening TS pole anchor rods and bolts and replaced with this rundown or snug wrench setting. One of torque wrenches the

feature is a simple switch whereas the other torque wrench the snug setting is adjusted by using a collar adjustment. Regardless of which type this replaces the 20% torque tightening value cycle for TS pole anchor rod tightening.

Figure 5-7 Cordless Battery Gun Torque Wrench with the "Rundown" Feature Setting

Due to the vast differences in the torque required for applications ranging from high strength bolts to large anchor rods in TS poles it is impossible for a single electric torque tool to cover such a broad range of sizes and torque specifications. For tasks involving a wide array of bolt and anchor rod sizes, TS pole installers typically need to invest in a series of torque wrenches to properly address the diverse torque requirements of different projects.

Figure 5-8 Electric Torque Tool Reference Guide

ELECTRIC TORQUE TOOL REFERENCE GUIDE

For Tightening TS Extension, Attachment, and Mast Arm HS Bolts and TS Pole Anchor Rods

TS Pole HS Bolts and Anchor Rods	TS extension and attachment ½" Dia. Bolts	TS Mast Arm 7/8" Dia. Bolts	TS 15-60 1 ½" Dia. Anchor Rods	TS 65 1 ¾" Dia. Anchor Rods	TS 70 and 75 2" Dia Anchor Rods	TS 80 2 ¼" Dia. Anchor Rods
Electric Torque Tool Model #	LST-0250 MNDOT BLUETOOTH					
		LST-0700 MNDOT BLUETOOTH				
		LST-1200 MNDOT BLUETOOTH				
			LST-2000 MNDOT BLUETOOTH			
				LST-3000 MNDOT BLUETOOTH		

NOTE: "MNDOT" included in the model # indicates 20 ft-lbs. Snug Torque/Rundown Setting for all Torque Tool Models. Must be included in the Model # when ordering.

Electric Torque Tool Model #s / Torque Range Values (ft-lbs.) / HS Bolt and Anchor Rod Diameters (inches)

LST-0250 MNDOT BLUETOOTH / 25 to 250	/ HS Bolts ½
LST-0700 MNDOT BLUETOOTH / 150 to 700	/ HS Bolts 7/8 Anchor Rods 1 ½
LST-1200 MNDOT BLUETOOTH / 200 to 1200	/ HS Bolts 7/8 Anchor Rods 1 ½ - 1 ¾
LST-2000 MNDOT BLUETOOTH / 325 to 2000	/ Anchor Rods 1 ½ - 2
LST-3000 MNDOT BLUETOOTH/ 500 to 3000	/Anchor Rods 1 ¾ - 2 ¼

5.4 Crows Foot Torque Wrench

As previously mentioned in section 5.1, a crows foot torque wrench or a torque wrench with a crows foot attachment is required for snugging the leveling (bottom) nuts to the specified torque. This is a change from the MnDOT Anchor Rod Tightening Handbook that required the leveling nuts to be tightened using a specified wrench length based on anchor rod diameter. The installer is required to pull the wrench in one smooth motion. The purpose behind it was to snug the leveling nuts with the bottom flat washers up against the bottom of the base plate thereby removing any gaps between the nut, washer, and base plate to provide a proper clamp. Some installers were confused by this step, and its purpose therefore ignoring the step completely. This is a crucial step for the anchor rod connections to ensure base plate is properly clamped between the top and bottom nuts and should never be skipped in the anchor rod tightening process.

MnDOT has used the term "snug tight" in the past to explain the leveling nuts must be snugged, however, if the installer is not an iron worker, they do not know what the snug tight term means even when provided a definition. Essentially the term is subjective and lacks precise standardized way of measuring, making it an arbitrary method compared to torque-controlled tightening.

Figure 5-9 Crows Foot Torque Wrench

For that reason, the crows foot torque wrench has been introduced into the anchor rod tightening procedure for TS poles to snug the leveling nuts to the required specified torque value shown in the ***TS Pole Series Anchor Rod Tightening Table*** in section 5.5 "TS Pole Series Anchor Rod Tightening Table (Torque Values).

5.5 TS Pole Series Anchor Rod Tightening Table (Torque Values)

Figure 5-10 Anchor Rod Pretensioning Table Torque Values

TS Pole Series Anchor Rod Pretensioning Table							
ASTM F1554 Anchor Rods							
Rod Ø	Rod Grade Spec. 3385	Standard Plate No. and Plan No.	TS Pole Structure Type	Rundown Snug Wrench Setting for Top Nuts	Torque (ft-lbs) for Leveling nuts *	60% Torque (ft-lbs)	100% Torque (ft-lbs)
1- 1/2 Inch	Type B Grade 55	8124 861	TS 15 Thru TS 55	X	70	420	700
1- 1/2 Inch	Type B Grade 55	8125 861	TS 60	X	70	420	700
1- 3/4 Inch	Type B Grade 55	8125 861	TS 65	X	110	659	1098
2 Inch	Type B Grade 55	8125 861	TS 70 TS 75	X	165	990	1650
2-1/4 Inch	Type B Grade 55	8125 861	TS 80	X	241	1448	2413

X= Top nuts are snugged using cordless torque wrench rundown or snug setting feature

***= Leveling nuts are snugged to the specified torque using a crows-foot torque wrench**

5.6 TS Pole Series Installation Procedure (Anchor Rod Tightening)

Figure 5-11 TS Pole Series Installation Procedure Steps

TS Pole Series Installation Procedures

The following are tightening steps and the reasons for the TS Pole Series. These steps are based on the MnDOT Anchor Rod Tightening Handbook "New Installation Procedures" but have been revised as new information has come to light and cordless battery gun torque wrenches are now required for tightening anchor rods.

1. Verify the Installation

The anchor rods should be F1554 or as specified for the project. Verify nuts are ASTM A563 heavy hex and washers are F436. Check that the anchor rods are clean, not damaged and plumb – not more than 1:40 slope or 1/4 in. in 10 in. (if rods are out of plumb or damaged, contact the project engineer). Finally, make sure the nuts can be easily run down all anchor rods by hand. Refer to contract documents for further installation requirements.

Why?

If the anchor rods are damaged or out of plumb, they will not tighten correctly and can result in higher forces on the anchor rods than expected.

2. Level the Leveling Nuts and Set Pole

The leveling nuts should be leveled with the washers on top (unless manufacturer requires additional special washers). No lubrication should be applied at this point. Set the pole in accordance with MnDOT's contract documents.

Why?

If the installation is out of plumb, there can be increased forces on the structure and anchor rods that can result in damage over the post's life.

3. Apply Lubricant

After the pole has been set apply lubricant only to the exposed anchor rod threads above the top washer, top face of the top washer, the face of the top nut that turns into the face of the washer, and the top nut threads as shown on Figure 5-2. Use an approved lubricant listed on MnDOT's APL.

Why?

Correct lubrication is required so the tightening properties of the anchor rods are the same. If the rod or washer are not lubricated, all of the tightening torque energy will be wasted on friction instead of clamping the baseplate. It is also important to lubricate the correct parts of the installation because the post base may slip in the clamped connection if the wrong areas are lubricated.

4. Turn Nuts by Hand

Turn the top nuts and the leveling nuts by hand removing any space or gaps in between the nuts, washers and the base plate. Number the top of the anchor rods as shown on Figure 5-4.

Why?

Hand tightening nuts first before using a wrench ensures proper thread engagement and alignment and allows for a quicker initial tightening process. It also allows for a visual inspection to see gaps between the nuts, washers and the base plate.

Steps 5. Thru 8. Continued Next Page

Figure 5-12 TS Pole Series Installation Procedure Steps Continued

5. Snug the Top Nuts First, Then the Leveling Nuts

A) Using a cordless battery gun torque wrench listed on MnDOT's APL, set the wrench to the rundown or snug feature and snug the top nuts in the required cross tightening pattern. Ensure the wrench is recording the data.

B) Using a crows foot torque wrench, or a torque wrench with a crows foot attachment, snug the leveling nuts in the required cross tightening pattern to the specified torque value found on the TS Pole Series Anchor Rod Pretension Table in Section 5.5 "TS Pole Series Anchor Rod Tightening Table Torque Values.

Why?

Snug the top nuts first before snugging the leveling nuts so the plate remains level.

If a leveling nut is nut snug against the bottom of the base plate the base plate won't be clamp between the nuts. Instead, the post and base plate will be pulled down towards the foundation, causing uneven forces and potentially loosening over time.

6. Torque top nuts in steps of 60%, and 100%, each individually in a cross tightening pattern

Look at the TS Pole Anchor Rod Pretensioning Table in Section 5.5 for the specified torque values for certain poles. Make sure to tighten all top nuts to the correct torque in the current step before going to the next higher step. Each step should be completed in a cross tightening pattern. Do NOT give the anchor rods extra torque, especially with smaller diameter anchor rods.

Why?

The torque steps and cross tightening pattern help with evenly distributing the clamp force in an anchor rod base. If the nuts are tightened immediately not in a cross tightening pattern, they will wedge one side of the base and cause unexpected and uneven forces in the anchor rods. The torque should be kept as close to the required amount as possible, if too much torque is used it can break an anchor rod.

7. Allow rods to relax for 10 minutes

Relax with the anchor rods for 10 minutes.

Why?

The surface of all of the connections is a little rough. During tightening, the higher parts of the rough connection are crushed and the galvanized coating can slip. It takes around 10 minutes for most of the initial crushing and slippage to catch up with the tightening force, so this needs to be allowed before re-tightening.

8. Re-Tighten to 100% Torque

After the 10 minute relaxation period, retighten the anchor rods with 100% torque in a cross tightening pattern. The nuts might not move, but that is okay.

Why?

Retightening has been shown to decrease the overall amount of relaxation clamp loss over the lifespan of an anchor rod connection. If the connections aren't retightened, they can lose around half of the applied clamping force over their life.

CHAPTER 6 BOLTED CONNECTIONS AND ORDER OF HARDWARE

Following figures show mast arm bolted connections and hardware, and pole extension and attachments.

Figure 6-1 TS 15-55 Top Chord and Bottom Chord Mast Arm Hardware

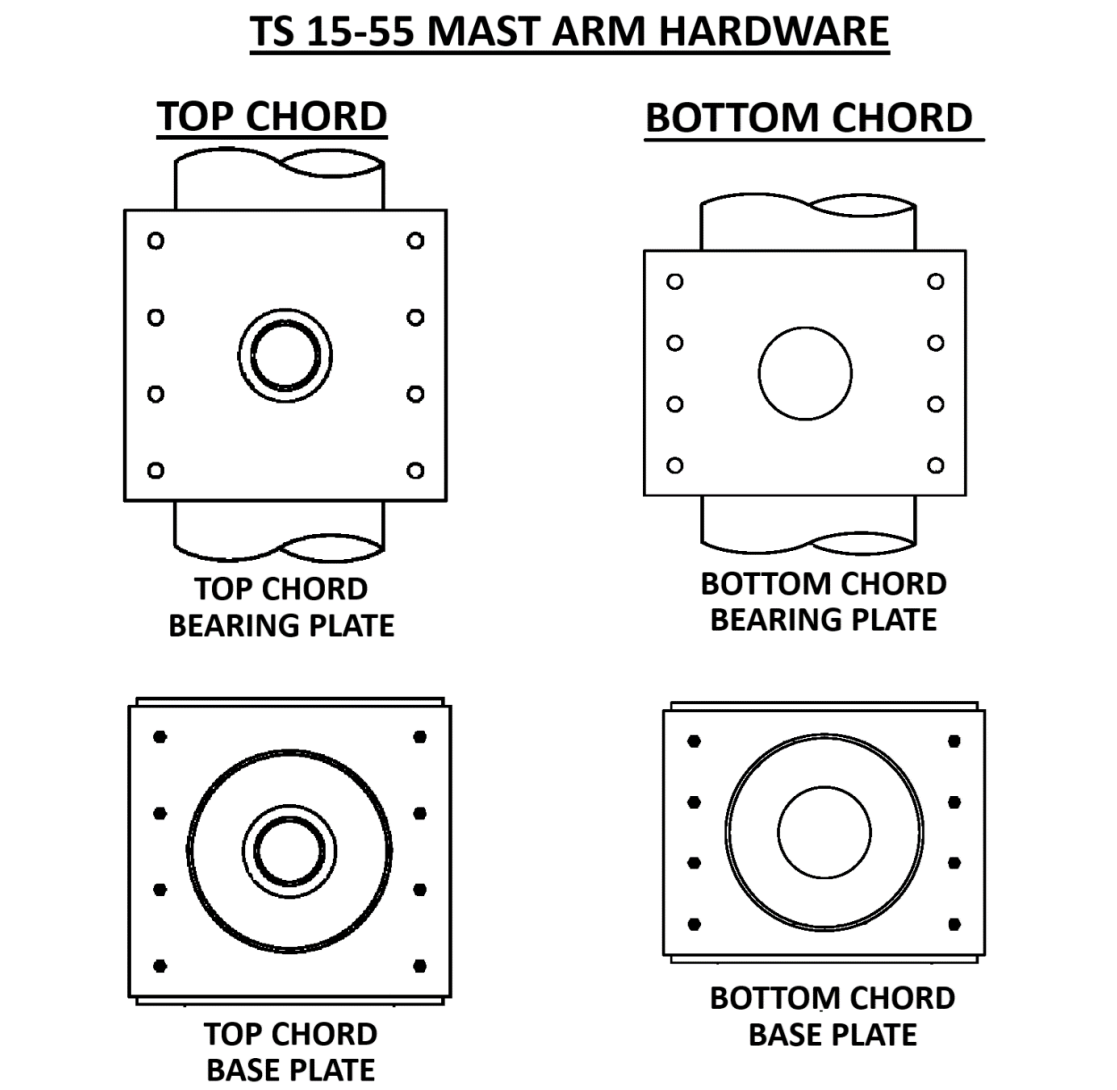


Figure 6-2 TS 60-80 Top Chord and Bottom Chord Mast Arm Hardware

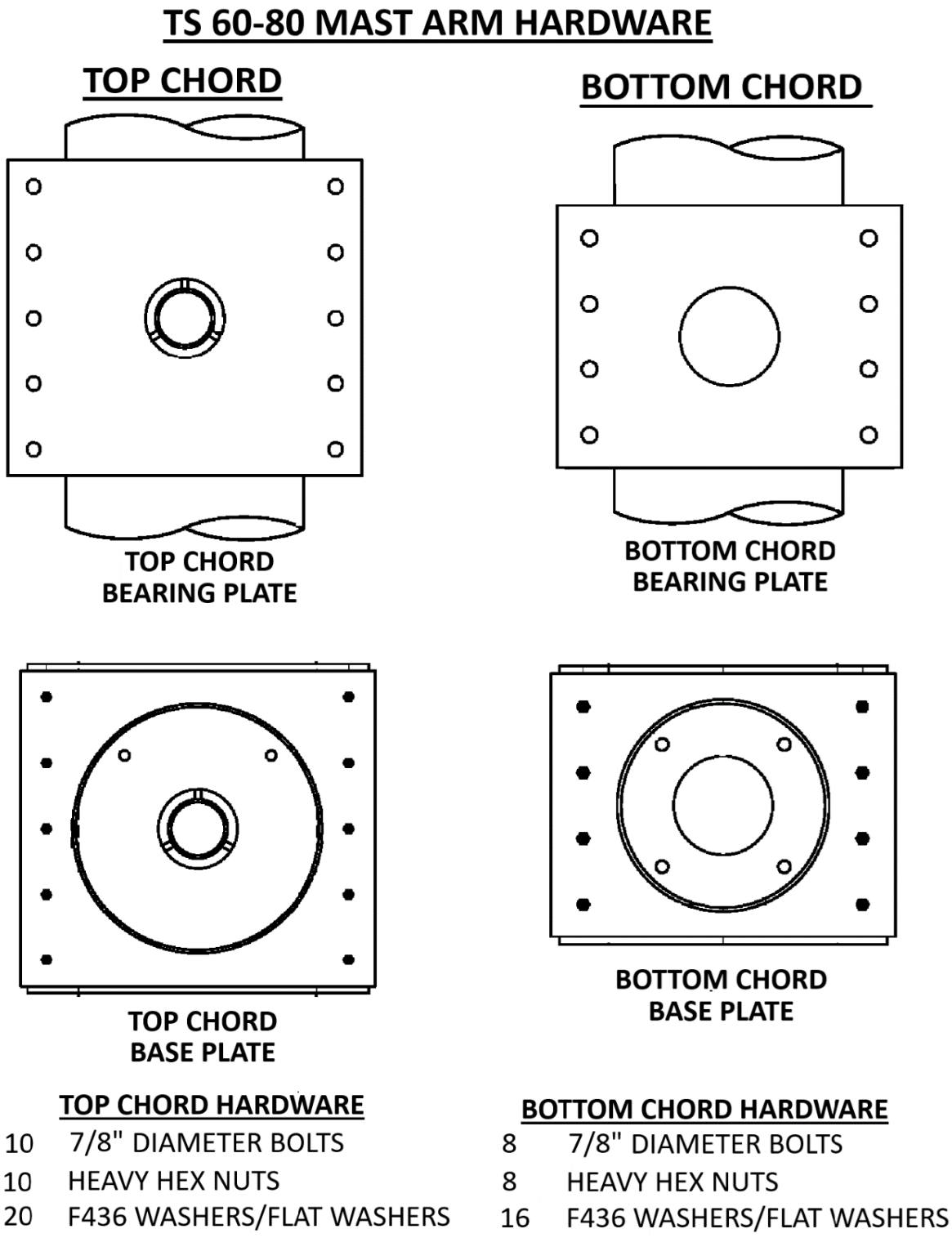


Figure 6-3 Mast Arm Bolting Order of Hardware

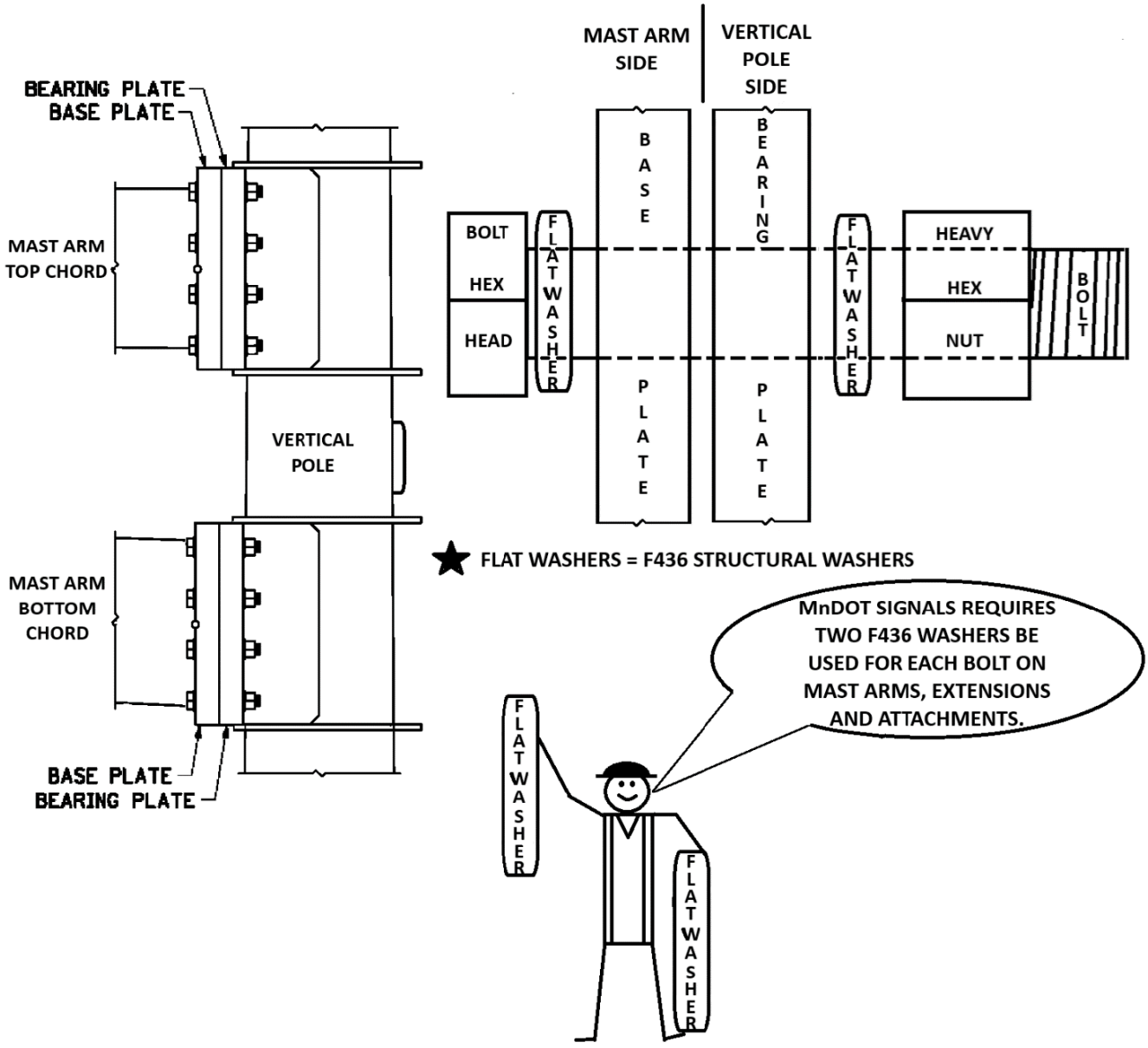
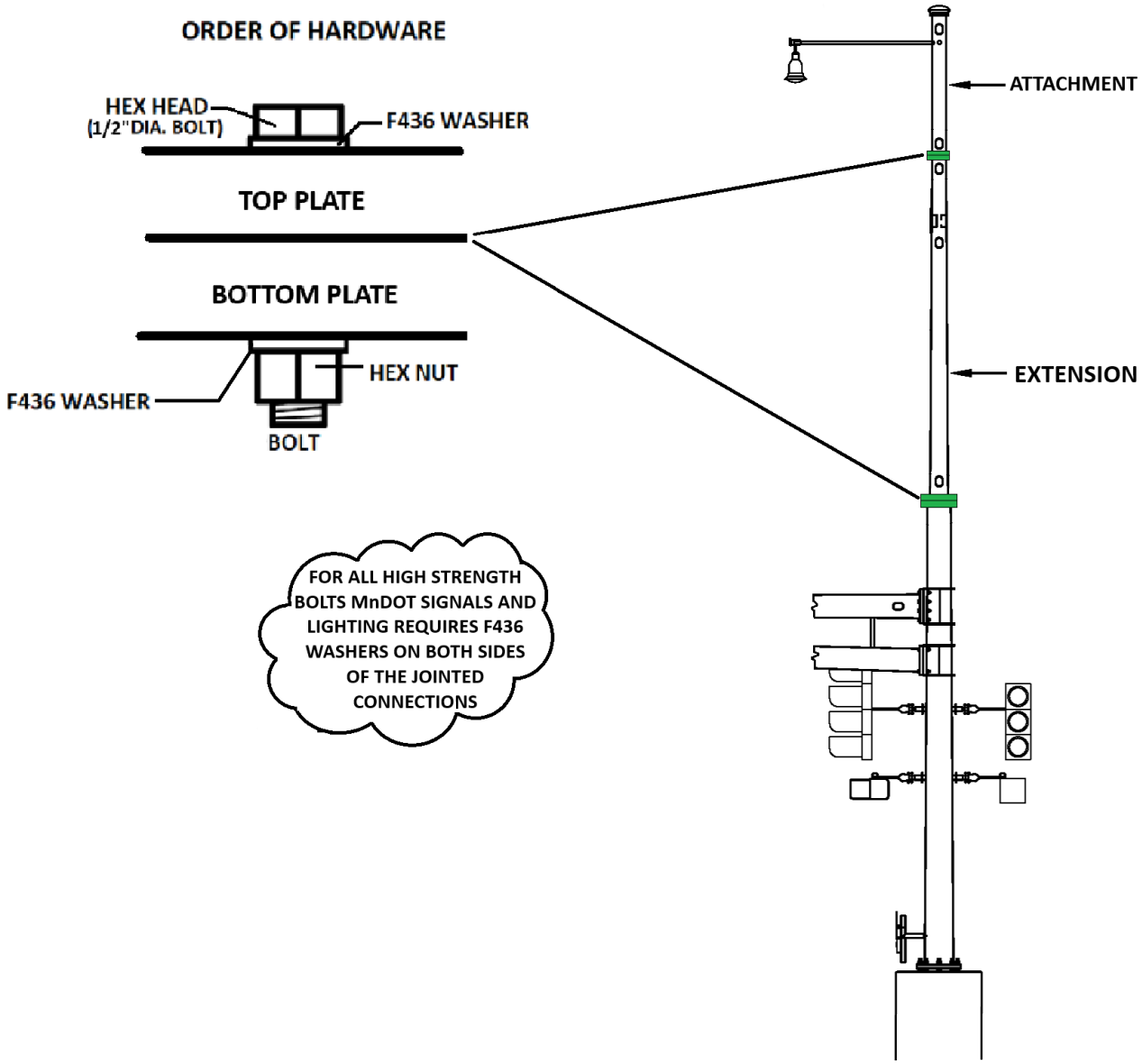


Figure 6-4 Order of Hardware for Extension and Attachment Bolting



6.1 Structural Bolting (High Strength Bolts)

The following information covers bolt tightening high strength bolts. High strength bolts are used for connecting TS pole mast arms, extensions, and attachments. When tightening high strength bolts, **DO NOT** reference MnDOT's Anchor Tightening Handbook for torque values. The torque values in MnDOT's Anchor Rod Tightening Handbook are for anchor rods not high strength bolts.

With new digital technologies MnDOT now requires the use of cordless battery torque gun wrenches listed on MnDOT's APL that have the capabilities to send out recorded torque data to an external device through wireless connection, essentially enabling real-time torque data transmission to signal inspectors that the torque values have been met for mast arm, extension, and attachment bolts. This technology eliminates the need to use DTI indicating media expelled washers.

Figure 6-5 Do Not Use the Anchor Rod Tightening Handbook for Tightening Bolts

6.1.1 Bolt Tightening

Because torque-controlled tightening is required for bolting, it is imperative that bolts, nuts, and washers are properly lubricated, and the torque wrenches have been calibrated before bolting begins.

Before bolting begins, discuss with the signal inspector how the bolt tightening data should be collected from the cordless battery torque gun wrench and submitted to the project engineer.

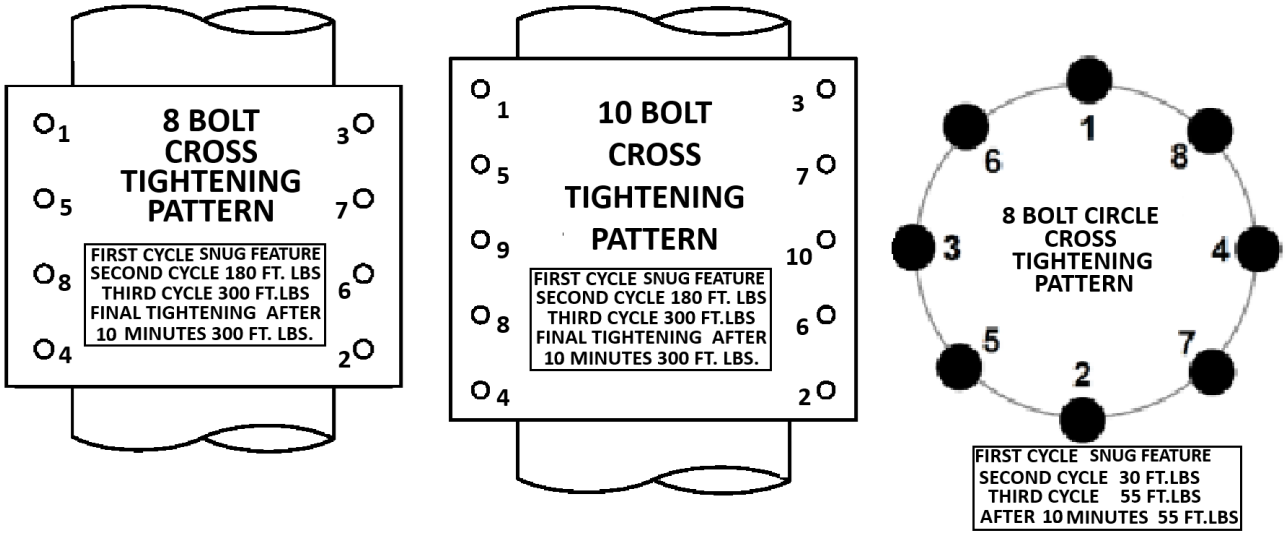
For mast arm 7/8- inch diameter bolts tighten the pre-lubricated bolts to a torque value of 300-foot pounds in the following order:

(1) Hand tighten the bolted connections
(2) Snug the bolted connections using the cordless battery gun torque wrenches rundown or snug feature in a cross-tightening pattern as shown in Figure 6-6
(3) Tighten bolts 60 percent (180-foot pounds) using cordless battery gun torque wrench in a cross-tightening pattern
(4) Tight bolts 100 percent (300-foot pounds) using cordless battery gun torque wrench in a cross-tightening pattern
(5) Allow to relax for 10 minutes
(6) Re-tighten to 100 percent torque value (300-foot pounds) using cordless battery gun torque wrench in a cross-tightening pattern.

For extensions and attachments 1/2-inch diameter bolts use a calibrated toque wrench and tighten the pre-lubricated bolts to a torque value of 55-foot pounds in the following order:

(1) Hand tighten the bolted connections
(2) Snug the bolted connections using the cordless battery gun torque wrenches rundown or snug feature in a cross-tightening pattern as shown in Figure 6-6
(3) Tighten bolts 60 percent (30-foot pounds) using cordless battery gun torque wrench in a cross-tightening pattern
(4) Tight bolts 100 percent (55-foot pounds) using cordless battery gun torque wrench in a cross-tightening pattern
(5) Allow to relax for 10 minutes
(6) Re-tighten to 100 percent torque value (55 foot pounds) using cordless battery gun torque wrench in a cross-tightening pattern.

Figure 6-6 Cross-Tightening Bolt Patterns

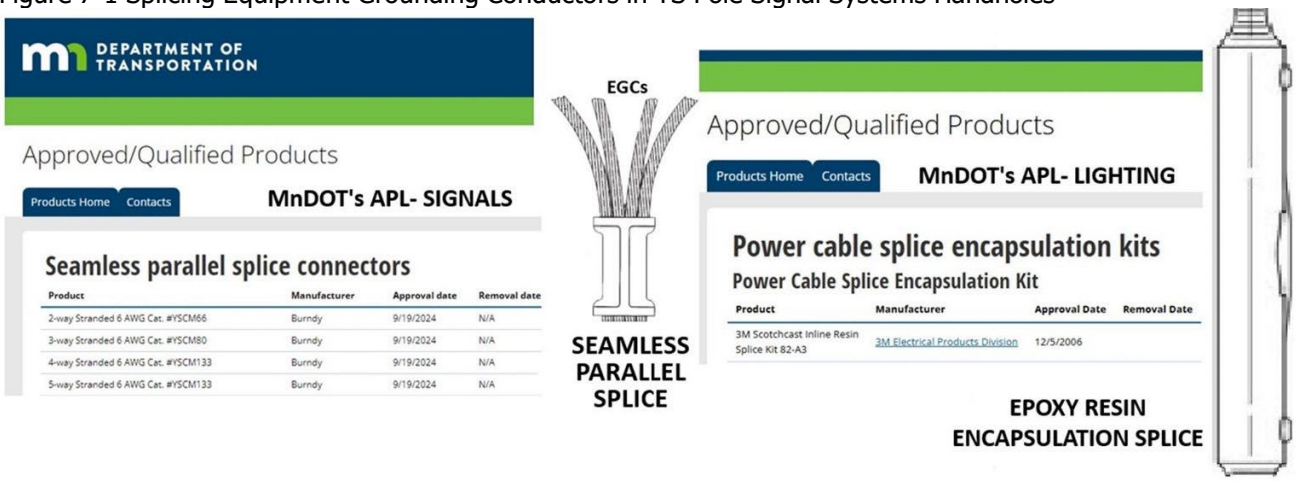


CHAPTER 7 TRAFFIC SIGNAL SYSTEMS GROUNDING

With the new TS Pole structure comes a new way of grounding TS Pole signal systems. The two substantial changes with the new grounding are no more ground rod electrodes in handholes and exothermic welds are no longer required. Instead, the new system requires the ground rods to be placed in the TS Pole Foundations as explained in Chapter 2 Foundations and EGCs, GECs, and LP conductors will be either connected using irreversible compression connectors or seamless splice connectors as specified in the projects Division SS provisions.

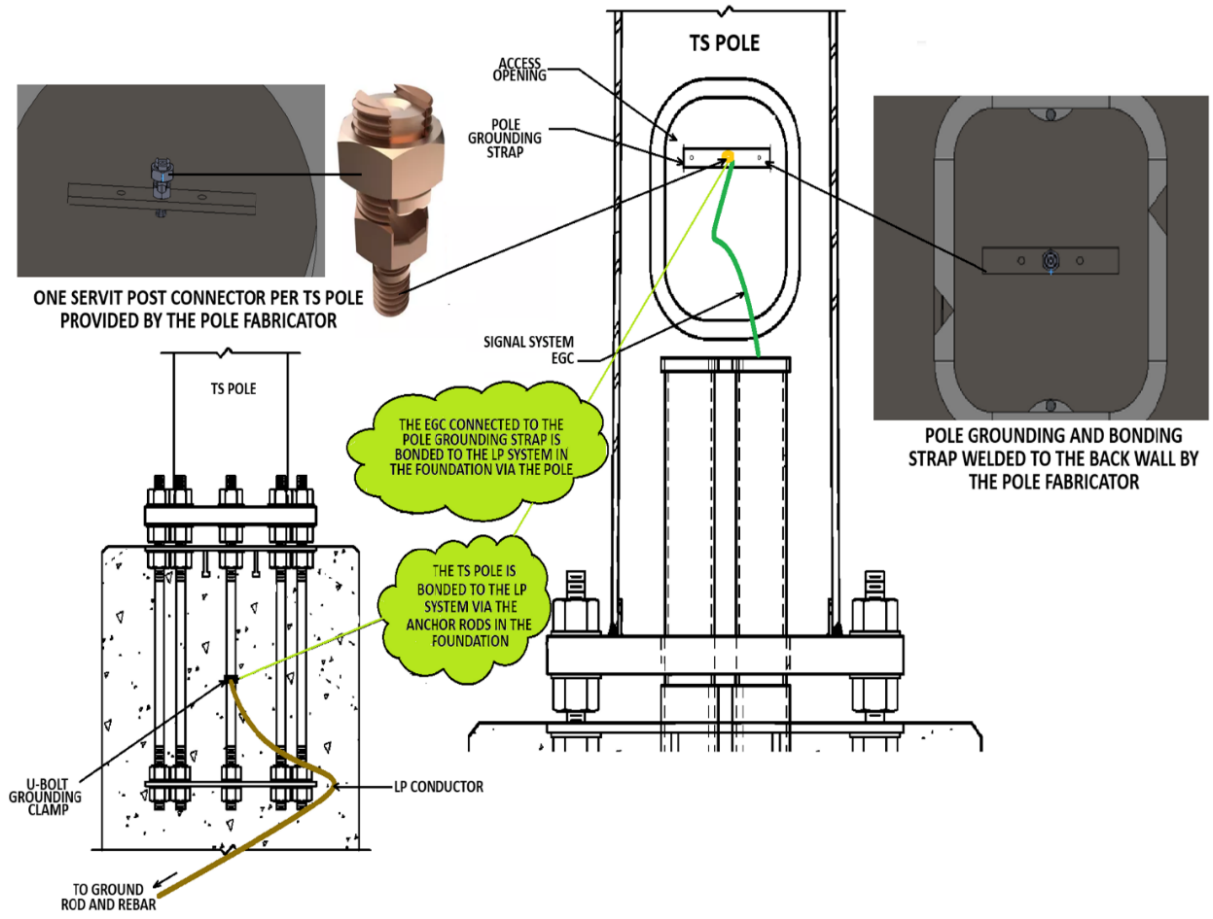
Equipment grounding conductors (EGCs) from the signal cabinets are required to be spliced in handholes with seamless splice connectors listed on MnDOT's APL- Signals. The entire crimped splice is then placed in an approved cable splice encapsulation kit listed on MnDOT's APL-Lighting.

Figure 7-1 Splicing Equipment Grounding Conductors in TS Pole Signal Systems Handholes



Install the encapsulation kit mold vertically with the top end open for placing the splice and the resin epoxy. Use electrical tape to seal off the spout holes and the bottom end of the mold to prevent the resin epoxy from leaking out. Ensure the resin epoxy completely covers the splice and bare portions of the conductors where the insulation was stripped to make the splice.

Figure 7-2 Bonding the EGC to the TS Pole



Provide grounding and bonding of metal poles and traffic signal components using equipment grounding conductors from the traffic signal cabinets grounding bus bar as shown on the plans. Terminate the equipment grounding conductors to the designated bonding termination grounding strap welded inside the base of the pole. Bond the TS Pole by terminating the equipment grounding conductor to the grounding servit post (on the welded ground strap) provided by the pole manufacturer. Additional servit posts if needed supplied by the contractor.

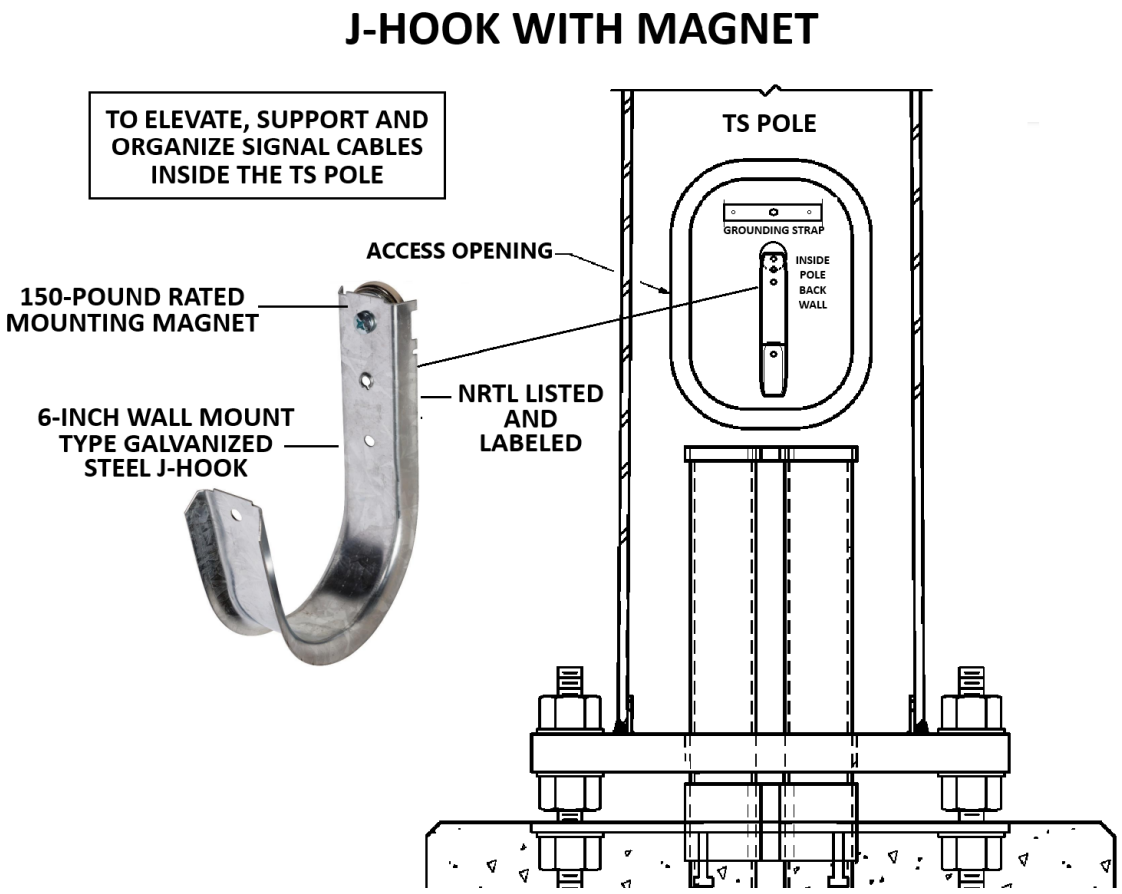
CHAPTER 8 TS POLE MISCELLANEOUS

8.1 J-Hook with Magnet

To elevate, support, and organize signal cables at the TS Pole access openings, provide J-Hooks with side mounted magnets meeting the following:

(1) NRTL Listed and Labeled
(2) 6-inch wall mount type galvanized steel J-Hook
(3) 150-pound rated mounting magnet
(4) J-Hook and magnet assembly rated for outdoor use
(5) Provide one J-hook per TS pole.

Figure 8-1 J-Hook with Magnet for Organizing Cables in the Base of TS Pole



8.2 Rodent Intrusion Barrier for TS Poles

In the next following months, there should be rodent intrusion barrier available listed on MnDOT's APL to fit inside the 10-inch opening for TS 15 -55 and the 12-inch opening for the TS 60-80. Depending on the barrier used
silicone sealant between the barrier and the baseplate may be required. Place a bead of silicone sealant between the barrier and the concrete foundation top.

8.3 TS Pole Mounting Adapter

There is an APS pushbutton pole mounting adapter specifically designed for the TS pole listed on MnDOT's APL-Signals.

Figure 8-2 New TS Pole Adapter Detail Drawing

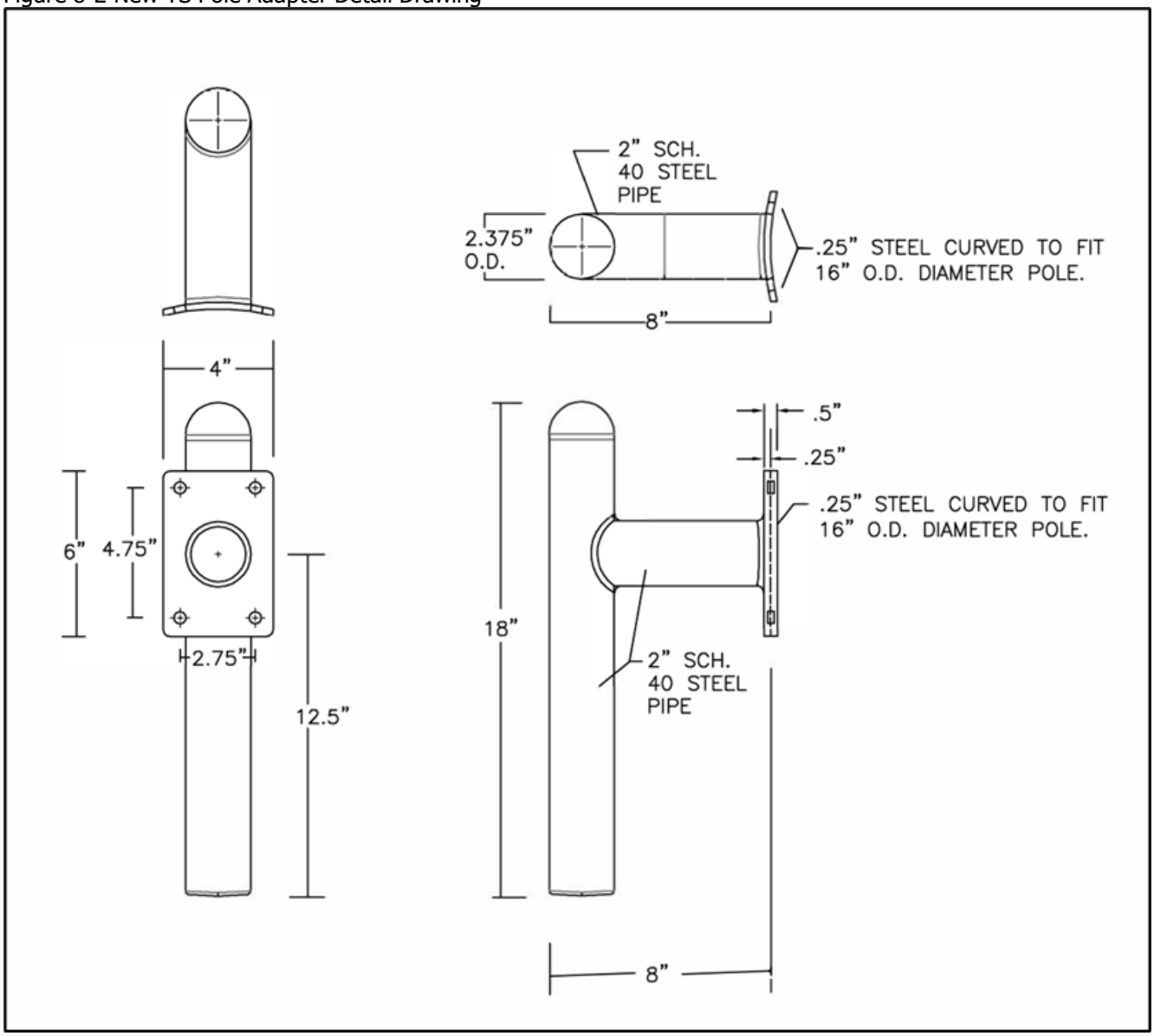
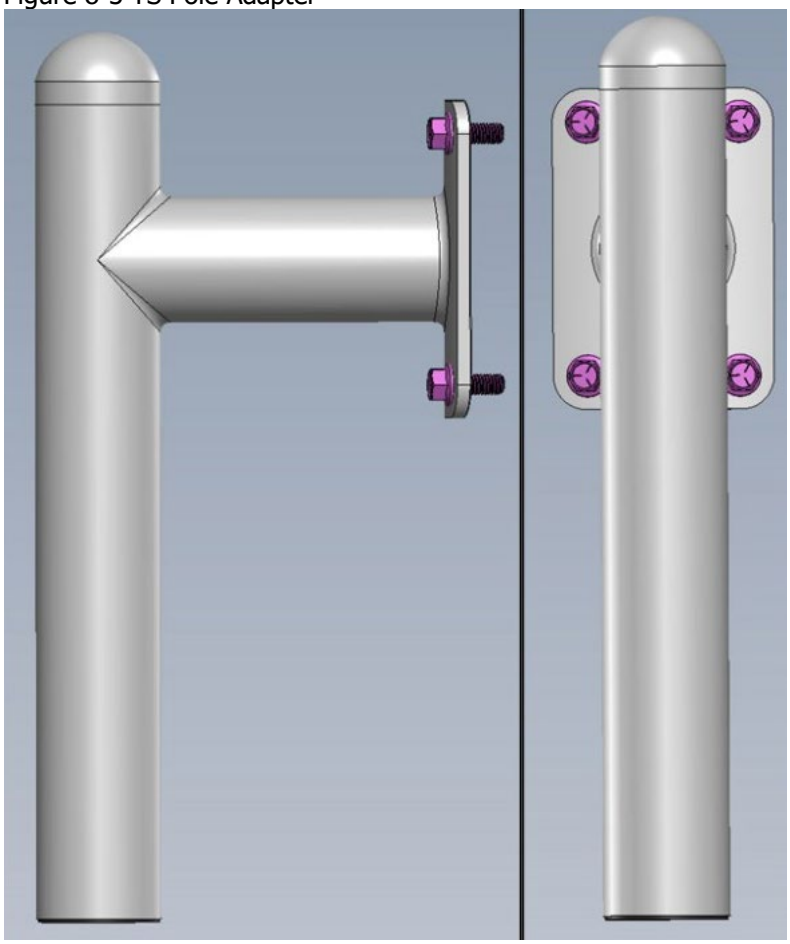
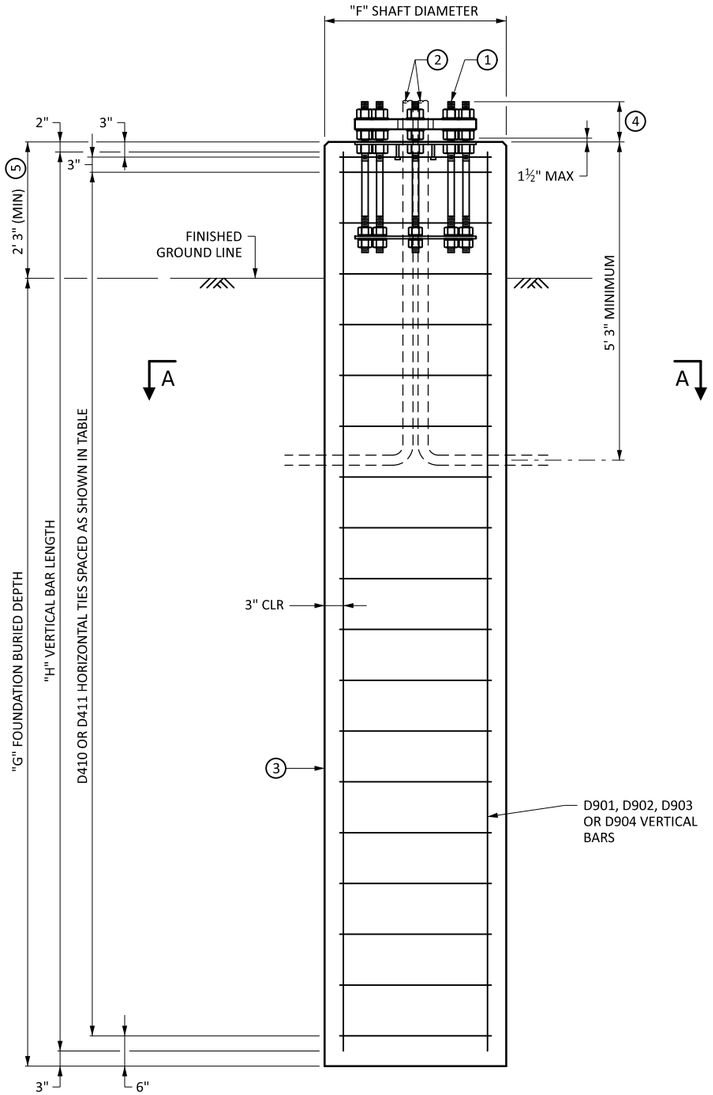


Figure 8-3 TS Pole Adapter



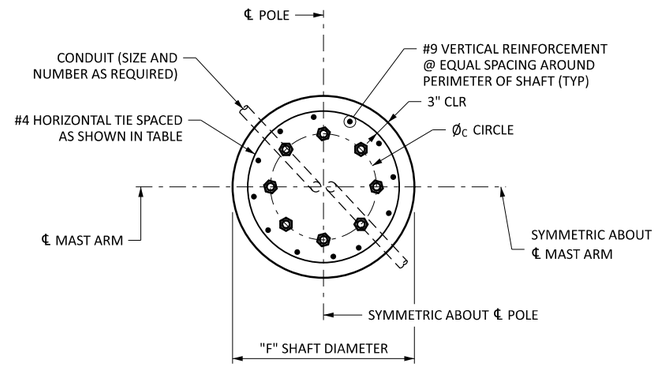


DRILLED SHAFT ELEVATION

FOUNDATION FOR 15' TO 40' MAST ARM SHOWN; OTHERS SIMILAR

DRILLED SHAFT FOUNDATION DATA			
DESCRIPTION	DIMENSION	MAST ARM LENGTH	
		15' TO 40'	45' TO 55'
SHAFT DIAMETER	F	3' 0"	4' 0"
FOUNDATION BURIED DEPTH	G	13' 0"	14' 0"
BOLT CIRCLE DIAMETER	$Ø_C$	1' 9"	1' 9"

DRILLED SHAFT REINFORCEMENT			
DESCRIPTION	DIMENSION	MAST ARM LENGTH	
		15' TO 40'	45' TO 55'
VERTICAL BAR MARK (#9)	-	D902	D904
VERTICAL BAR LENGTH	H	14' 10"	15' 10"
NUMBER OF VERTICAL BARS	-	12	20
HORIZONTAL TIE BAR MARK (#4)	-	D410	D411
NUMBER OF HORIZONTAL TIES	-	19	17
MAX HORIZONTAL TIE SPACING	-	10"	12"
HORIZONTAL TIE LENGTH	-	9' 8"	12' 9"



SECTION A-A

GEOTECHNICAL PARAMETERS

CONTACT MnDOT FOUNDATIONS UNIT FOR DETERMINATION OF SUBSURFACE INVESTIGATION REQUIREMENTS.

THE FOUNDATION DIMENSIONS SHOWN ON THIS SHEET ARE DESIGNED ASSUMING THE WATER TABLE IS 1.5' BELOW GRADE OR LOWER AND THE IN-SITU SOIL PROPERTIES MEET OR EXCEED THE FOLLOWING MINIMUM VALUES:

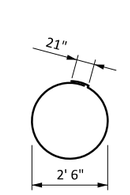
SANDY SOILS
UNIT WEIGHT = 125 PCF
FRICTION ANGLE = 30°

CLAY SOILS
UNIT WEIGHT = 125±10 PCF
COHESION = 1000 PSF
FRICTION ANGLE = 0°

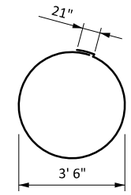
A SPECIAL FOUNDATION DESIGN IS REQUIRED WHEN THE SPECIFIED VALUES, CONDITIONS, OR BOTH LISTED ABOVE ARE NOT MET.

BAR BENDING DIAGRAMS

BENT BAR DIMENSIONS GIVEN ARE OUT-TO-OUT. DETERMINE ACTUAL BAR LENGTHS BASED ON THE DETAIL DIMENSIONS SHOWN IN THE BAR BENDING DIAGRAMS.



D410



D411

NOTES

COLD CONCRETE CONSTRUCTION JOINTS ARE NOT PERMITTED.

GALVANIZE STEEL COMPONENTS IN ACCORDANCE WITH SPEC 3394.

FURNISH AND INSTALL PREFORMED JOINT FILLER IN ACCORDANCE WITH SPEC 3702 BETWEEN THE FOUNDATION AND SIDEWALK OR OTHER CONCRETE AREAS. THEN SEAL THE JOINT BETWEEN THE FOUNDATION AND SIDEWALK OR CONCRETE AREA WITH SILICONE SEALANT IN ACCORDANCE WITH SPEC 3722.

FURNISH AND INSTALL 3G52 CONCRETE MIX IN ACCORDANCE WITH SPEC 2461. PLACE AND CURE CONCRETE IN ACCORDANCE WITH SPEC 2401.

PROVIDE ¾" CHAMFER ON THE EXPOSED TOP EDGE OF THE FOUNDATION.

EXCAVATE, BACKFILL, AND COMPACT AROUND THE FOUNDATION IN ACCORDANCE WITH SPEC 2451.

POSITION FOUNDATION CONDUITS INSIDE THE ANCHOR ROD ASSEMBLY. CAP ENDS UNTIL CABLES ARE INSTALLED.

ALLOW THE FOUNDATION TO CURE FOR AT LEAST 7 DAYS AFTER CONCRETE POURING OPERATIONS BEFORE INSTALLING POLES.

PROVIDE GRADE 60 DEFORMED BILLET REINFORCEMENT BARS IN ACCORDANCE WITH AASHTO M31 GRADE 60, SPEC 2471, AND SPEC 3301.

DRILLED SHAFT FOUNDATIONS ARE DESIGNED FOR THE CAST-IN-PLACE CONCRETE TO BE POURED DIRECTLY AGAINST THE SOILS SURROUNDING THE DRILLED SHAFT. CONCRETE FORMS ARE REQUIRED FOR THE 27" ABOVE THE FINISHED GROUNDLINE OR SIDEWALK AND PERMANENT CASING MAY BE USED FOR NO MORE THAN 25 PERCENT OF THE TOTAL FOUNDATION DEPTH BELOW FINISHED GRADE OR SIDEWALK. DO NOT USE PERMANENT CASING FOR MORE THAN 25 PERCENT OF THE ENTIRE DEPTH OF THE DRILLED SHAFT.

(1) SEE STANDARD PLATE 8124 FOR ANCHOR ROD ASSEMBLY DETAILS.

(2) SEE CONDUIT DETAIL ON STANDARD PLAN 5-297.861 SHEET 5 OF 5.

(3) EXCAVATE TO NEAT LINES AND PLACE CONCRETE AGAINST UNDISTURBED SOIL.

(4) SEE ANCHOR ROD PLACEMENT DETAIL ON STANDARD PLAN 5-297.861 SHEET 5 OF 5.

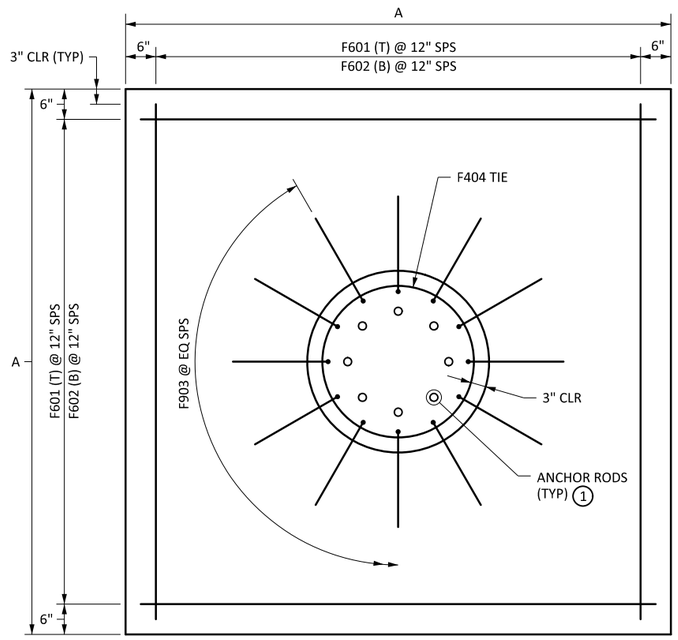
(5) INCREASE FOUNDATION PROJECTION AS REQUIRED TO PROVIDE A VERTICAL CLEARANCE FROM THE BOTTOM OF ALL SIGNS AND SIGNAL HEADS (INCLUDING BACKGROUND SHIELDS) TO THE PAVEMENT OF NOT LESS THAN 17.50' NOR MORE THAN 19.00'. INCREASE OVERALL FOUNDATION LENGTH TO PROVIDE THE MINIMUM FOUNDATION BURIED DEPTH. INCREASE LONGITUDINAL BAR LENGTH TO PROVIDE THE INDICATED COVER.

LEAD EXPERT OFFICE	EDWARD LUTGEN OFFICE DIRECTOR BRIDGE OFFICE	POLE FOUNDATION TYPE TS DRILLED SHAFT FOUNDATIONS FOR 15' TO 55' MAST ARMS	APPROVED: 12-01-2025 REVISED:	THOMAS STYRBICKI STATE DESIGN ENGINEER	STANDARD PLAN 5-297.861	1 OF 5

DEPARTMENT OF TRANSPORTATION			STANDARD PLAN	STATE PROJ. NO.	SHEET NO.
				TRUNK HWY.	TOTAL SHEETS

SPREAD FOOTING FOUNDATION DATA					
POLE TYPE	MAST ARM LENGTH	SPREAD FOOTING DIMENSIONS			
		A	B	C	D
TS15-TS40	15', 20', 25', 30', 35', & 40'	9' 6"	3' 3"	3' 0"	9' 0"
TS45-TS55	45', 50', & 55'	11' 0"	3' 6"	4' 0"	10' 6"

SPREAD FOOTING REINFORCEMENT						
BAR	MAST ARM LENGTH				SHAPE	LOCATION
	15' TO 40'		45' TO 55'			
	NO.	LENGTH	NO.	LENGTH		
F601	20	9' 0"	22	10' 6"		FOOTING TOP
F602	20	11' 0"	22	12' 6"		FOOTING BOTTOM
F903	12	8' 0"	20	8' 0"		PEDESTAL VERTICAL
(4) F404	7	9' 8"	---	---		PEDESTAL TIE
(4) F405	---	---	7	12' 9"		PEDESTAL TIE



SPREAD FOOTING PLAN

GEOTECHNICAL PARAMETERS

CONTACT MnDOT FOUNDATIONS UNIT FOR DETERMINATION OF SUBSURFACE INVESTIGATION REQUIREMENTS.

THE FOUNDATION DIMENSIONS SHOWN ON THIS SHEET ARE DESIGNED ASSUMING THE WATER TABLE IS BELOW THE BOTTOM OF FOOTING ELEVATION OR LOWER AND THE IN-SITU SOIL PROPERTIES MEET OR EXCEED THE FOLLOWING MINIMUM VALUES:

SANDY SOILS
UNIT WEIGHT = 125 PCF
FRICTION ANGLE = 30°

CLAY SOILS
UNIT WEIGHT = 125±10 PCF
COHESION = 1000 PSF
FRICTION ANGLE = 0°

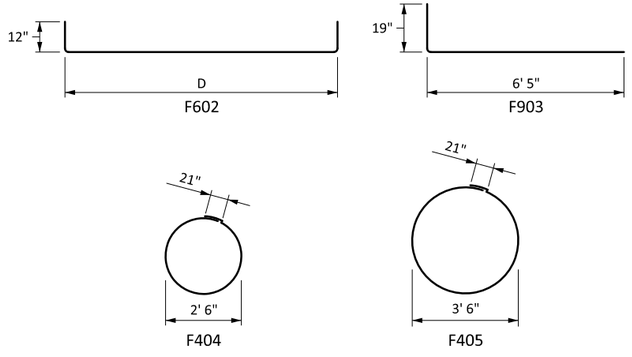
A SPECIAL FOUNDATION DESIGN IS REQUIRED WHEN THE SPECIFIED VALUES, CONDITIONS, OR BOTH LISTED ABOVE ARE NOT MET.

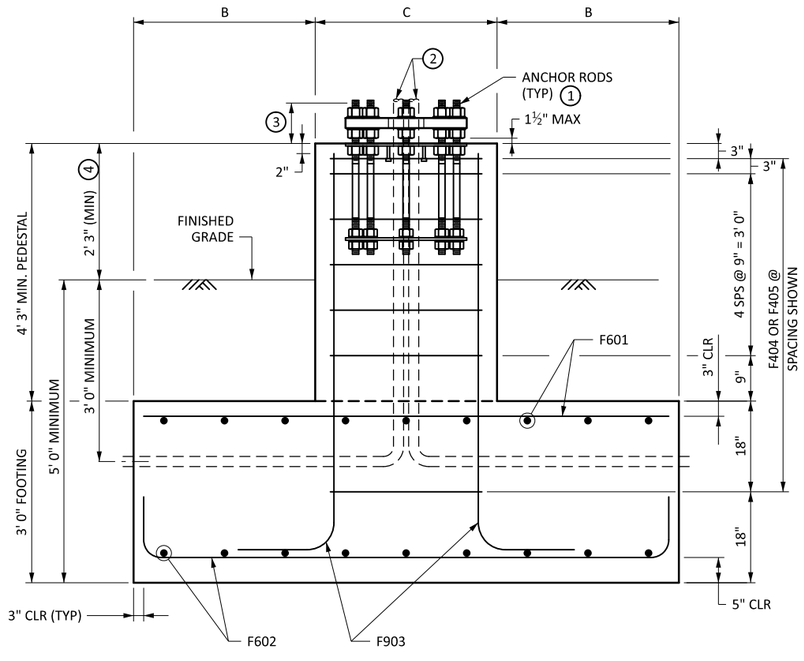
SPREAD FOOTINGS ARE DESIGNED BASED ON AN ALLOWABLE BEARING PRESSURE OF 2.50 KSF.

IF THE SOIL BEARING CAPACITY IS LESS THAN 2.50 KSF, OBTAIN APPROVAL FROM THE DISTRICT SOILS ENGINEER.

BAR BENDING DIAGRAMS

BENT BAR DIMENSIONS GIVEN ARE OUT-TO-OUT. DETERMINE ACTUAL BAR LENGTHS BASED ON THE DETAIL DIMENSIONS SHOWN IN THE BAR BENDING DIAGRAMS.





SPREAD FOOTING ELEVATION

NOTES

FURNISH AND INSTALL PREFORMED JOINT FILLER IN ACCORDANCE WITH SPEC. 3702 BETWEEN THE FOUNDATION AND SIDEWALK OR OTHER CONCRETE AREAS. THEN SEAL THE JOINT BETWEEN THE FOUNDATION AND SIDEWALK OR CONCRETE AREA WITH SILICONE SEALANT IN ACCORDANCE WITH SPEC 3722.

FURNISH AND INSTALL 3G52 CONCRETE MIX IN ACCORDANCE WITH SPEC 2461. PLACE AND CURE CONCRETE IN ACCORDANCE WITH SPEC 2401.

PROVIDE ¾" CHAMFER ON THE EXPOSED TOP EDGE OF THE FOUNDATION.

EXCAVATE, BACKFILL, AND COMPACT AROUND THE FOUNDATION IN ACCORDANCE WITH SPEC 2451.

POSITION FOUNDATION CONDUITS INSIDE THE ANCHOR ROD ASSEMBLY. CAP ENDS UNTIL CABLES ARE INSTALLED.

ALLOW THE FOUNDATION TO CURE FOR AT LEAST 7 DAYS AFTER CONCRETE POURING OPERATIONS BEFORE INSTALLING POLES.

PROVIDE GRADE 60 DEFORMED BILLET REINFORCEMENT BARS IN ACCORDANCE WITH AASHTO M31 GRADE 60, SPEC 2471, AND SPEC 3301.

(1) SEE STANDARD PLATE 8124 FOR ANCHOR ROD ASSEMBLY DETAILS.

(2) SEE CONDUIT DETAIL ON STANDARD PLAN 5-297.861 SHEET 5 OF 5.

(3) SEE ANCHOR ROD PLACEMENT DETAIL ON STANDARD PLAN 5-297.861 SHEET 5 OF 5.

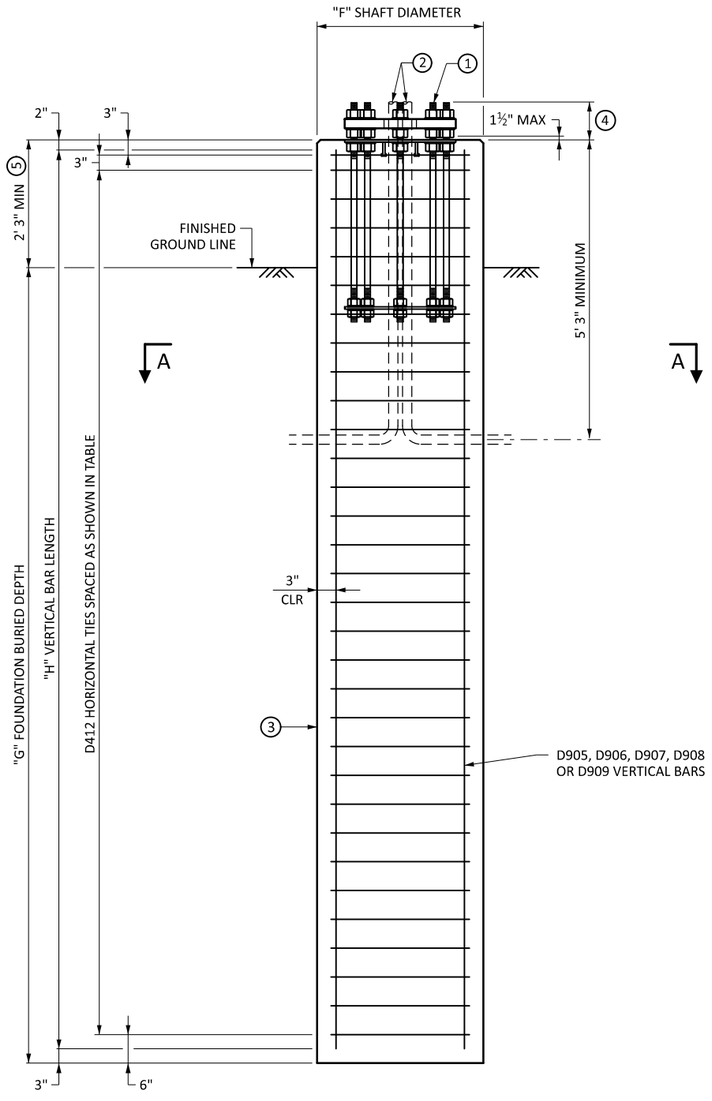
(4) INCREASE FOUNDATION PROJECTION AS REQUIRED TO PROVIDE A VERTICAL CLEARANCE FROM THE BOTTOM OF ALL SIGNS AND SIGNAL HEADS (INCLUDING BACKGROUND SHIELDS) TO THE PAVEMENT OF NOT LESS THAN 17.50' NOR MORE THAN 19.00'. INCREASE PEDESTAL LENGTH TO PROVIDE THE MINIMUM FOOTING BURIED DEPTH FOR FROST PROTECTION. INCREASE VERTICAL BAR LENGTH AND, IF NEEDED, ADD ADDITIONAL F404 OR F405 TO PROVIDE THE INDICATED COVER.

	LEAD EXPERT OFFICE	EDWARD LUTGEN OFFICE DIRECTOR BRIDGE OFFICE	POLE FOUNDATION TYPE TS SPREAD FOOTING FOR 15' TO 55' MAST ARMS	APPROVED: 12-01-2025 REVISED:	THOMAS STYRBICKI STATE DESIGN ENGINEER	STANDARD PLAN 5-297.861	2 OF 5

DEPARTMENT OF TRANSPORTATION		STANDARD PLAN	STATE PROJ. NO.	SHEET NO.
			TRUNK HWY.	TOTAL SHEETS

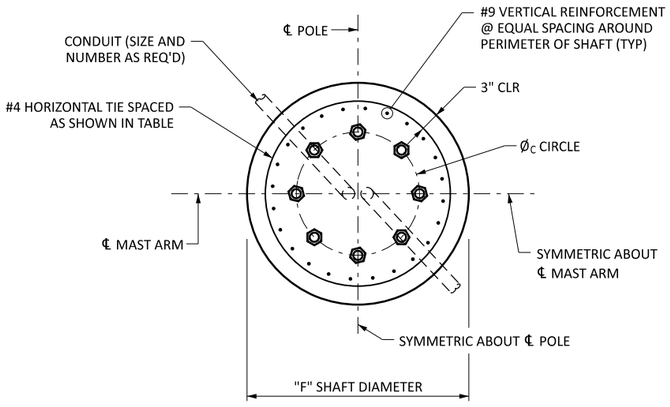
DRILLED SHAFT FOUNDATION DATA						
DESCRIPTION	DIMENSION	MAST ARM LENGTH				
		60'	65'	70'	75'	80'
SHAFT DIAMETER	F	4' 6"	4' 6"	4' 6"	4' 6"	4' 6"
FOUNDATION BURIED DEPTH	G	14' 0"	16' 6"	19' 6"	22' 0"	24' 6"
BOLT CIRCLE DIAMETER	$Ø_C$	2' 5"	2' 5"	2' 7"	2' 9"	2' 9"

DRILLED SHAFT REINFORCEMENT						
DESCRIPTION	DIMENSION	MAST ARM LENGTH				
		60'	65'	70'	75'	80'
VERTICAL BAR MARK (#9)	-	D905	D906	D907	D908	D909
VERTICAL BAR LENGTH	H	15' 10"	18' 4"	21' 4"	23' 10"	26' 4"
NUMBER OF VERTICAL BARS	-	24	24	24	24	24
HORIZONTAL TIE BAR MARK (#4)	-	D412	D412	D412	D412	D412
NUMBER OF HORIZONTAL TIES	-	32	37	43	48	53
MAX HORIZONTAL TIE SPACING	-	6"	6"	6"	6"	6"
HORIZONTAL TIE LENGTH	-	14' 4"	14' 4"	14' 4"	14' 4"	14' 4"



DRILLED SHAFT ELEVATION

FOUNDATION FOR 60' MAST ARM SHOWN; OTHERS SIMILAR



SECTION A-A

GEOTECHNICAL PARAMETERS

CONTACT MnDOT FOUNDATIONS UNIT FOR DETERMINATION OF SUBSURFACE INVESTIGATION REQUIREMENTS.

THE FOUNDATION DIMENSIONS SHOWN ON THIS SHEET ARE DESIGNED ASSUMING THE WATER TABLE IS 1.5' BELOW GRADE OR LOWER AND THE IN-SITU SOIL PROPERTIES MEET OR EXCEED THE FOLLOWING MINIMUM VALUES:

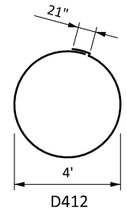
SANDY SOILS
UNIT WEIGHT = 125 PCF
FRICTION ANGLE = 30°

CLAY SOILS
UNIT WEIGHT = 125±10 PCF
COHESION = 1000 PSF
FRICTION ANGLE = 0°

A SPECIAL FOUNDATION DESIGN IS REQUIRED WHEN THE SPECIFIED VALUES, CONDITIONS, OR BOTH LISTED ABOVE ARE NOT MET.

BAR BENDING DIAGRAMS

BENT BAR DIMENSIONS GIVEN ARE OUT-TO-OUT. DETERMINE ACTUAL BAR LENGTHS BASED ON THE DETAIL DIMENSIONS SHOWN IN THE BAR BENDING DIAGRAMS.



D412

NOTES

COLD CONCRETE CONSTRUCTION JOINTS ARE NOT PERMITTED FOR DRILLED SHAFTS.

GALVANIZE STEEL COMPONENTS IN ACCORDANCE WITH SPEC 3394.

FURNISH AND INSTALL PREFORMED JOINT FILLER IN ACCORDANCE WITH SPEC 3702 BETWEEN THE FOUNDATION AND SIDEWALK OR OTHER CONCRETE AREAS. THEN SEAL THE JOINT BETWEEN THE FOUNDATION AND SIDEWALK OR CONCRETE AREA WITH SILICONE SEALANT IN ACCORDANCE WITH SPEC 3722.

FURNISH AND INSTALL 3G52 CONCRETE MIX IN ACCORDANCE WITH SPEC 2461. PLACE AND CURE CONCRETE IN ACCORDANCE WITH SPEC 2401.

PROVIDE ¾" CHAMFER ON THE EXPOSED TOP EDGE OF THE FOUNDATION.

EXCAVATE, BACKFILL, AND COMPACT AROUND THE FOUNDATION IN ACCORDANCE WITH SPEC 2451.

POSITION FOUNDATION CONDUITS INSIDE THE ANCHOR ROD ASSEMBLY. CAP ENDS UNTIL CABLES ARE INSTALLED.

ALLOW THE FOUNDATION TO CURE FOR AT LEAST 7 DAYS AFTER CONCRETE POURING OPERATIONS BEFORE INSTALLING POLES.

PROVIDE GRADE 60 DEFORMED BILLET REINFORCEMENT BARS IN ACCORDANCE WITH AASHTO M31 GRADE 60, SPEC 2471, AND SPEC 3301.

DRILLED SHAFT FOUNDATIONS ARE DESIGNED FOR THE CAST-IN-PLACE CONCRETE TO BE POURED DIRECTLY AGAINST THE SOILS SURROUNDING THE DRILLED SHAFT. CONCRETE FORMS ARE REQUIRED FOR THE 27" ABOVE THE FINISHED GROUNDLINE OR SIDEWALK AND PERMANENT CASING MAY BE USED FOR NO MORE THAN 25 PERCENT OF THE TOTAL FOUNDATION DEPTH BELOW FINISHED GRADE OR SIDEWALK. DO NOT USE PERMANENT CASING FOR MORE THAN 25 PERCENT OF THE ENTIRE DEPTH OF THE DRILLED SHAFT.

1. SEE STANDARD PLATE 8125 FOR ANCHOR ROD ASSEMBLY DETAILS.
2. SEE CONDUIT DETAIL ON STANDARD PLAN 5-297.861 SHEET 5 OF 5.
3. EXCAVATE TO NEAT LINES AND PLACE CONCRETE AGAINST UNDISTURBED SOIL.
4. SEE ANCHOR ROD PLACEMENT DETAIL ON STANDARD PLAN 5-297.861 SHEET 5 OF 5.
5. INCREASE FOUNDATION PROJECTION AS REQUIRED TO PROVIDE A VERTICAL CLEARANCE FROM THE BOTTOM OF ALL SIGNS AND SIGNAL HEADS (INCLUDING BACKGROUND SHIELDS) TO THE PAVEMENT OF NOT LESS THAN 17.50' NOR MORE THAN 19.00'. INCREASE OVERALL FOUNDATION LENGTH TO PROVIDE THE MINIMUM FOUNDATION BURIED DEPTH. INCREASE LONGITUDINAL BAR LENGTH TO PROVIDE THE INDICATED COVER.

LEAD EXPERT OFFICE	EDWARD LUTGEN OFFICE DIRECTOR BRIDGE OFFICE	POLE FOUNDATION TYPE TS DRILLED SHAFT FOUNDATIONS FOR 60' TO 80' MAST ARMS	APPROVED: 12-01-2025 REVISED:	THOMAS STYRBICKI STATE DESIGN ENGINEER	STANDARD PLAN 5-297.861	3 OF 5

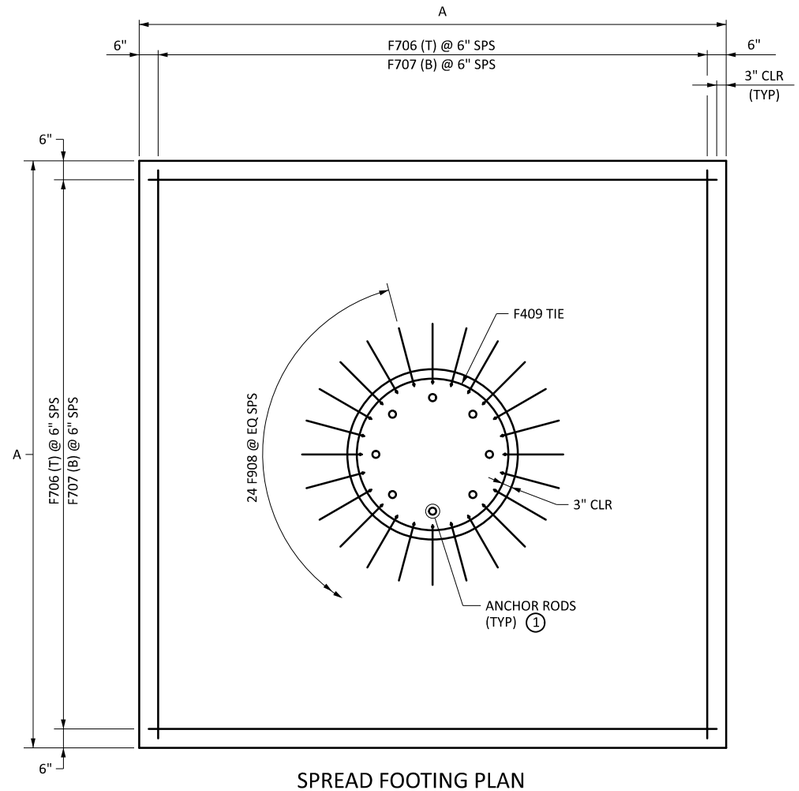
DEPARTMENT OF TRANSPORTATION		STANDARD PLAN	STATE PROJ. NO.	SHEET NO.
			TRUNK HWY.	TOTAL SHEETS

SPREAD FOOTING FOUNDATION DATA

POLE TYPE	MAST ARM LENGTH	SPREAD FOOTING DIMENSIONS		
		A	B	C
TS60	60' 0"	12' 6"	4' 0"	12' 0"
TS65	65' 0"	13' 0"	4' 3"	12' 6"
TS70	70' 0"	14' 0"	4' 9"	13' 6"
TS75	75' 0"	15' 0"	5' 3"	14' 6"
TS80	80' 0"	15' 6"	5' 6"	15' 0"

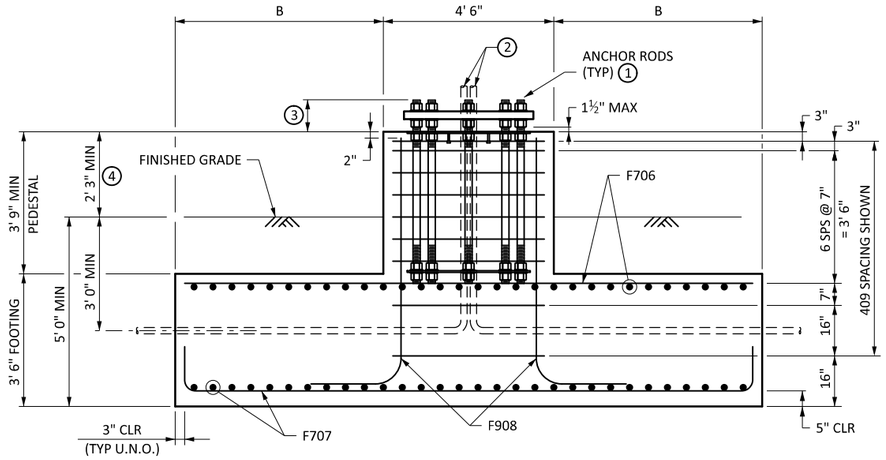
SPREAD FOOTING REINFORCEMENT

BAR	MAST ARM LENGTH										SHAPE	LOCATION
	60'		65'		70'		75'		80'			
	NO.	LENGTH	NO.	LENGTH	NO.	LENGTH	NO.	LENGTH	NO.	LENGTH		
F706	48	12' 0"	50	12' 6"	54	13' 6"	58	14' 6"	60	15' 0"		FOOTING TOP
F707	48	14' 4"	50	14' 10"	54	15' 10"	58	16' 10"	60	17' 4"		FOOTING BOTTOM
F908	24	8' 1"	24	8' 1"	24	8' 1"	24	8' 1"	24	8' 1"		PEDESTAL VERTICAL
F409	10	14' 4"	10	14' 4"	10	14' 4"	10	14' 4"	10	14' 4"		PEDESTAL TIE



SPREAD FOOTING PLAN

80' MAST ARM FOUNDATION SHOWN; 60' TO 75' MAST ARM FOUNDATION SIMILAR



SPREAD FOOTING ELEVATION

GEOTECHNICAL PARAMETERS

CONTACT MnDOT FOUNDATIONS UNIT FOR DETERMINATION OF SUBSURFACE INVESTIGATION REQUIREMENTS.

THE FOUNDATION DIMENSIONS SHOWN ON THIS SHEET ARE DESIGNED ASSUMING THE WATER TABLE IS BELOW THE BOTTOM OF FOOTING ELEVATION OR LOWER AND THE IN-SITU SOIL PROPERTIES MEET OR EXCEED THE FOLLOWING MINIMUM VALUES:

SANDY SOILS	CLAY SOILS
UNIT WEIGHT = 125 PCF	UNIT WEIGHT = 125±10 PCF
FRICTION ANGLE = 30°	COHESION = 1000 PSF
	FRICTION ANGLE = 0°

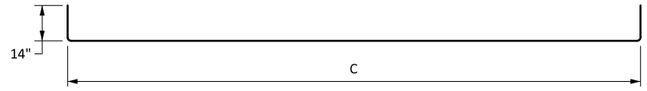
A SPECIAL FOUNDATION DESIGN IS REQUIRED WHEN THE SPECIFIED VALUES, CONDITIONS, OR BOTH LISTED ABOVE ARE NOT MET.

SPREAD FOOTINGS ARE DESIGNED BASED ON AN ALLOWABLE BEARING PRESSURE OF 2.50 KSF.

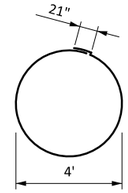
IF THE SOIL BEARING CAPACITY IS LESS THAN 2.50 KSF, OBTAIN APPROVAL FROM THE DISTRICT SOILS ENGINEER.

BAR BENDING DIAGRAMS

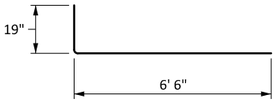
BENT BAR DIMENSIONS GIVEN ARE OUT-TO-OUT. DETERMINE ACTUAL BAR LENGTHS BASED ON THE DETAIL DIMENSIONS SHOWN IN THE BAR BENDING DIAGRAMS.



F707



F409



F908

NOTES

FURNISH AND INSTALL PREFORMED JOINT FILLER IN ACCORDANCE WITH SPEC 3702 BETWEEN THE FOUNDATION AND SIDEWALK OR OTHER CONCRETE AREAS. THEN SEAL THE JOINT BETWEEN THE FOUNDATION AND SIDEWALK OR CONCRETE AREA WITH SILICONE SEALANT IN ACCORDANCE WITH SPEC 3722.

FURNISH AND INSTALL 3G52 CONCRETE MIX IN ACCORDANCE WITH SPEC 2461. PLACE AND CURE CONCRETE IN ACCORDANCE WITH SPEC 2401.

PROVIDE ¾" CHAMFER ON THE EXPOSED TOP EDGE OF THE FOUNDATION.

EXCAVATE, BACKFILL, AND COMPACT AROUND THE FOUNDATION IN ACCORDANCE WITH SPEC 2451.

POSITION FOUNDATION CONDUITS INSIDE THE ANCHOR ROD ASSEMBLY. CAP ENDS UNTIL CABLES ARE INSTALLED.

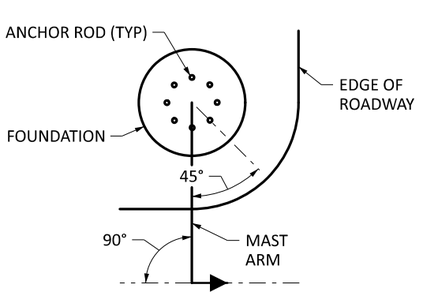
ALLOW THE FOUNDATION TO CURE FOR AT LEAST 7 DAYS AFTER CONCRETE POURING OPERATIONS BEFORE INSTALLING POLES.

PROVIDE GRADE 60 DEFORMED BILLET REINFORCEMENT BARS IN ACCORDANCE WITH AASHTO M31 GRADE 60, SPEC 2471, AND SPEC 3301.

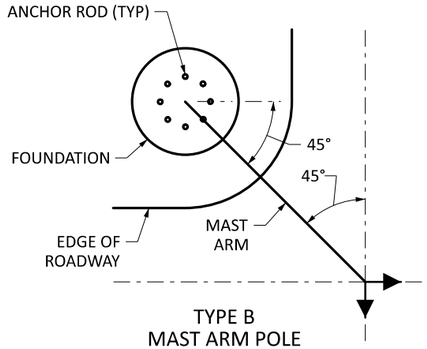
1. SEE STANDARD PLATE 8125 FOR ANCHOR ROD ASSEMBLY DETAILS.
2. SEE CONDUIT DETAIL ON STANDARD PLAN 5-297.861 SHEET 5 OF 5.
3. SEE ANCHOR ROD PLACEMENT DETAIL ON STANDARD PLAN 5-297.861 SHEET 5 OF 5.
4. INCREASE FOUNDATION PROJECTION AS REQUIRED TO PROVIDE A VERTICAL CLEARANCE FROM THE BOTTOM OF ALL SIGNS AND SIGNAL HEADS (INCLUDING BACKGROUND SHIELDS) TO THE PAVEMENT OF NOT LESS THAN 17.50 FEET NOR MORE THAN 19.00 FEET. INCREASE PEDESTAL LENGTH TO PROVIDE THE MINIMUM FOOTING BURIED DEPTH FOR FROST PROTECTION. INCREASE VERTICAL BAR LENGTH TO PROVIDE THE INDICATED COVER.

LEAD EXPERT OFFICE	EDWARD LUTGEN OFFICE DIRECTOR BRIDGE OFFICE	POLE FOUNDATION TYPE TS SPREAD FOOTING FOR 60' TO 80' MAST ARMS	APPROVED: 12-01-2025 REVISED:	THOMAS STYRBICKI STATE DESIGN ENGINEER	STANDARD PLAN 5-297.861	4 OF 5

DEPARTMENT OF TRANSPORTATION		STANDARD PLAN	STATE PROJ. NO.	SHEET NO.
			TRUNK HWY.	TOTAL SHEETS



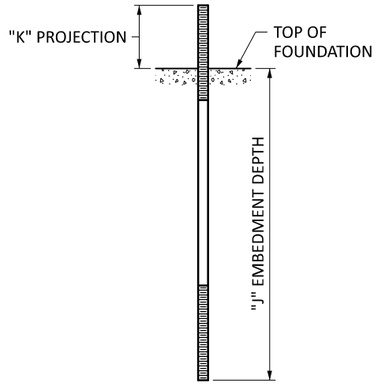
TYPE A
MAST ARM POLE



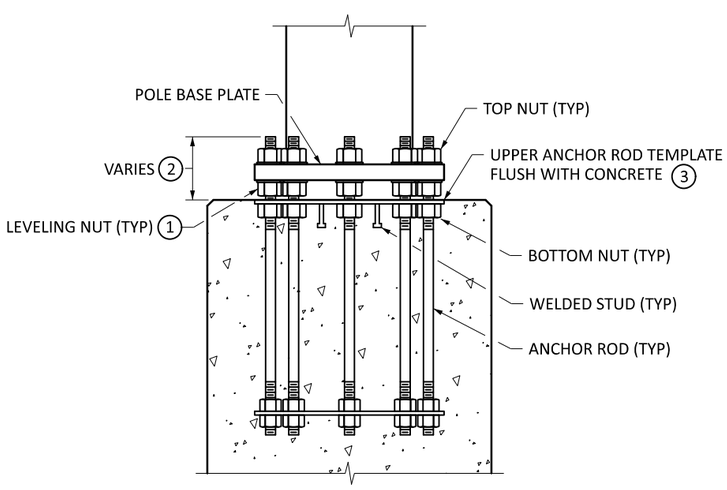
TYPE B
MAST ARM POLE

ANCHOR ROD PLACEMENT

POLE TYPE	ANCHOR ROD EMBEDMENT DEPTH	ANCHOR ROD PROJECTION
	J	K
TS15-TS55	22"	8"
TS60	34"	8"
TS65	38"	9"
TS70	42"	10"
TS75	42"	10"
TS80	48"	11"

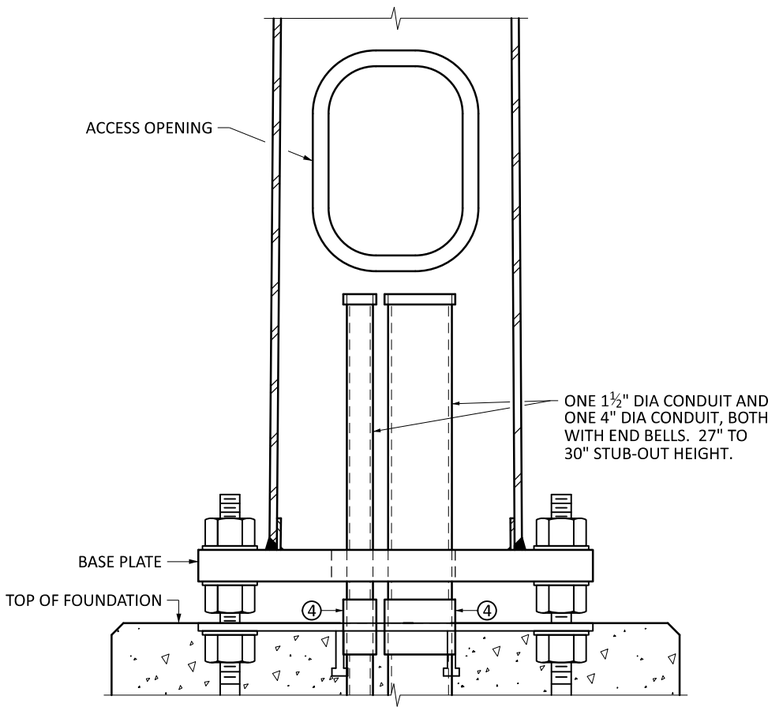


ANCHOR ROD PLACEMENT DETAIL



PARTIAL ELEVATION

SHOWING ANCHOR ROD ASSEMBLY AND HEX NUT POSITIONS AFTER POLE INSTALLATION



CONDUIT

FOUNDATION REINFORCEMENT NOT SHOWN FOR CLARITY

NOTES

(1) USE THE LEVELING NUTS TO TEMPORARILY SECURE THE UPPER ANCHOR ROD TEMPLATE BEFORE CONCRETE OPERATIONS. LEAVE THE NUTS SECURE AGAINST THE TEMPLATE UNTIL POLE INSTALLATION. USE THE REQUIRED HARDWARE FOR DOUBLE-NUT ANCHOR ROD CONNECTIONS IN ACCORDANCE WITH SPEC 2545.

(2) PROTECT ANCHOR ROD THREADS AND LEVELING NUTS ABOVE THE ANCHOR ROD TEMPLATE FROM CONCRETE CONTAMINATION.

(3) REMOVE SURFACE CONTAMINANTS AND APPLY SILICONE SEALANT TO THE UPPER TEMPLATE AROUND THE ANCHOR RODS, ANCHOR ROD HOLES, AND THE INNER AND OUTER EDGES WHERE THE PLATE MEETS CONCRETE. USE AN APPROVED SILICONE JOINT SEALANT FOUND ON MnDOT'S APL UNDER BRIDGE PRODUCTS.

(4) PVC COUPLING.

	LEAD EXPERT OFFICE: EDWARD LUTGEN, OFFICE DIRECTOR, BRIDGE OFFICE	POLE FOUNDATION TYPE TS ANCHOR RODS AND CONDUIT DETAILS	APPROVED: 12-01-2025 REVISED:	THOMAS STYRBICKI STATE DESIGN ENGINEER	STANDARD PLAN 5-297.861	5 OF 5

DEPARTMENT OF TRANSPORTATION			STANDARD PLAN	STATE PROJ. NO.	SHEET NO.
				TRUNK HWY.	TOTAL SHEETS