Why Source Inspection Is Critical For Transmission Structures?

Ajay Mallik [1], P.E., Clinton Char [2], P.E., Dewan Jamir, P.E. [3]

[1] Ajay Mallik, P.E., President & CEO, SANPEC, Inc. Ph: 832-392-4230; Email: ajmallik@sanpec.com
[2] Clinton Char, P.E., Project Engineer, Southern California Edison, Ph: 714-255-4824; Email:Clinton.Char@sce.com
[3] Dewan Jamir, P.E., Senior Electrical Engineer, Burns & McDonnell, Ph: 714-989-2059; Email: djamir@burnsmcd.com

ABSTRACT

Transmission Line Structures such as Steel Poles and Lattice Towers play a very critical role in building robust and reliable transmission infrastructures. Due to increasing demands in today's fast paced manufacturing environment, it is more important than ever to receive quality conforming finished products from the global suppliers. These structures are complex in design and require a high degree of skill and experience to properly manufacture and meet the quality standards. With scheduled line outages difficult to obtain, or condensed construction timelines resulting from fixed completion dates, utility customers and construction contractors cannot afford to discover any problems with the structure fit-up or other quality issues only after the products arrive at the job site. Recent rapid growth in demand for transmission structures has put a great deal of pressure on suppliers to increase production output. At the same time, many of those suppliers (domestics & overseas) are also dealing with severe shortages of knowledgeable and experienced shop personnel (particularly welders, fitters, quality personnel, bundling, galvanizing, dulling etc.). The utility customers are losing millions of dollars each year in downtime and start-up delays due to receipt of faulty or poor quality transmission structure materials.

This paper gives guidance and background to address the benefits of source inspection during fabrication, assembly, and testing before shipment. It also outlines the necessary and valuable steps to be considered by the suppliers in order to meet or exceed the specification requirements.

1. INTRODUCTION

A source inspection is a quality inspection in which utility customers (clients) require a quality check before the material is received. There are many reasons to utilize source inspection services. While most customers aim to increase efficiency and profitability by minimizing the expense related to production errors, there are various other benefits that are often overlooked. As most of the manufacturing world has evolved to a "Just in Time" delivery model, source inspection services become increasingly critical to the assurance of on-time delivery of properly specified transmission structures and its components. And aside from product shipment delays, mitigating risk up front at the supplier point is the best way to minimize liability for product failures and construction delays. Due to orders exceeding current production capacity, many suppliers are having sub-assemblies and components fabricated by 3rd party vendors. Quality assurance and control needs to be monitored by either suppliers or outsourced vendors by highly qualified representatives at site. Source inspection insures that the suppliers and 3rd party subcontractors are aware of the owner's specification and that the owner's will only accept quality finished products that meet those specifications.

It is a very common practice today that the utility customers rely on a supplier's own quality assurance program and in-house inspection process for manufacturing transmission structures. Most of the customers provide detailed technical specification along with an important statement that all

manufacturing related work shall be performed in accordance with the highest industry standards and in compliance with all applicable codes. Due to large recent investment in transmission infrastructure and subsequent growing demand for transmission structures, utility customers are making compromise in pre-approval process and allowing new suppliers from both domestic and international level. There are huge shortages of skilled and experienced manpower industry wise which is affecting the quality of finished products. Customers are facing several challenges due to poor quality materials at job site and losing millions of dollars in downtime and start-up delays. Today's fast paced manufacturing world, it is highly recommended that the utility customers should implement source inspection or third part inspection process at the manufacturing plant. This paper provides general guidelines of source inspection for Steel Tubular Poles and Lattice Steel Towers.

2. BENEFITS

Key benefits of source inspection:

- Insure all parties clearly understand the "order requirements" before start of fabrication.
- Verify the supplier's intentions to meet the order requirements "before" the start of fabrication
- Verify that supplier's quality control, inspection and test capabilities match the need for the project.
- Resolve discrepancies and deviations from the specs during fabrication and before shipment
- Independent determination of product conformity/nonconformity.
- Independent observations of all welding activities for conformance to AWS D1.1 Structural Welding Code.
- Insure that the customer receives the quality product meeting all expectations
- Mitigating Project Risk and Maximizing Profitability (cost savings)
- Increases flexibility for changes in workload
- Assure improvements in supplier, program, and business performance
- Overall quality of supplier's finished products and materials improves drastically

3. INSPECTION FLOW CHART

Fig. 1: Sample Source Inspection Flow Chart

4. INSPECTION PROCESS

The process of performing source inspections mirrors the process of the life cycle in designing and procuring the structures. The performance of inspections along the entire life of the project ensures that

all issues are looked at and that there are "no surprises" in the end. There are three basic steps which must be taken to ensure an effective source inspection program. These steps are:

1. Develop and create a source inspection plan that includes procedures, checklists, forms, and training programs.

2. Screen and qualify Project Inspectors to perform the detailed inspections. The selection of the Inspectors should be based on technical skills and proximity to suppliers.

3. Effective program management and technical support utilizing online tools for real-time access to schedules, status, results, and reports.

Each of these steps will be discussed in detail.

A. Source Inspection Plan Development

Prior to the start of fabrication a source inspection plan needs to be developed for the specific product being manufactured. For the purposes of this paper, that product will be steel transmission structures. This would include tubular steel poles as well as lattice steel towers. The plan needs to define the structure of the source inspection program. Major items in the plan should include: the items and processes being inspected, the pass/fail criteria which will be established for those inspections, the frequency of the inspections, the reports which will be provided, the reporting mechanism for any material deficiencies and the overall management of the information generated from the inspections.

The first step in the development of a source inspection plan is to develop an inspection document which provides specifics on what will be inspected; the steps involved in the inspection and the pass/fail criteria for each of the steps. Perhaps the best document to use in the development of the inspection document is the structural specifications. The design and fabrication of all structures should be defined in the structural specifications for the project. The specifications should provide all the details in which the structures will be designed and fabricated. At a minimum the specifications should include the structure shop drawings or load trees, the grade of steel to be used, any unique tests or properties which the steel needs to meet, the fabrication and delivery schedule, and specifics on any details which will be included in the structure design. The inspection document should mirror the structure specification to ensure that all key features of the specification are inspected and documented.

Once the inspection document has been developed, checklists and forms may be created to assist the inspectors in performing and recording the results of their inspections.

Depending on the client's requirements, the inspections may need to be performed at the fabricator's suppliers. In the case of steel poles and towers, the inspections may need to be performed at the steel mills to verify that the steel has the mechanical and physical properties as required by the fabricator and client.

B. Inspectors

The source inspections should be performed by either in-house inspectors from the client or by third party contractors representing the client. Depending on the complexity of the inspections and the reputation of the supplier, the inspectors can perform their inspections on a random basis or be embedded at the supplier's facilities throughout the fabrication period. When using a third party contractor it is best to use an organization whose expertise is in type of inspections to be performed. In that manner they will be able to understand the fabrication processes to be performed and will be able identify any unusual issues

which may arise. To minimize costs, it is recommended to use inspectors in the immediate vicinity of the supplier's facilities.

The inspectors should have an educational and/or work experience background in the type of inspections which are to be performed. They should have knowledge of all aspects of the fabrication process and all associated pertinent codes and standards. Since these materials will be fabricated for use within the US, the inspectors need to be knowledgeable on the AWS D1.1 Structural Welding Code-Steel as well as ASTM, IEEE, ASCE and other US standards. When using inspectors for materials fabricated outside of the US, the inspectors should be able to communicate effectively in both English and the native language of the country in which the materials are being fabricated. The inspectors should be able to communicate effectively in both speaking and written communications.

Prior to the start of the inspection program, the inspectors need to be provided with a copy of the structural specification and copies of all inspection documents, checklists and forms. They should be briefed on the use of each of the forms and understand the proper reporting processes. They need to be provided with guidelines on what needs to be inspected, the frequency of the inspections and what constitutes acceptance/rejection. Training and personal protection equipment should be provided to ensure that they are in compliance with the safety requirements of the supplier that they are inspecting.

Prior to the start of inspections, a meeting should be held between the client, the inspectors and the supplier's representatives to formally introduce the inspectors. During the meeting the supplier should be provided with copies of all inspection documents. The supplier should also be informed as to what will be inspected and what will constitute acceptance/rejection. During the meeting the ground rules for the inspections need to be determined and agreed upon. The inspectors will be on the supplier's premises and should abide by all of the supplier's standard policies and procedures. For example, while all suppliers will welcome the inspectors, each supplier will have differing policies on the use of cameras in their facilities. Photo documentation is a part of the source inspection process; however, care must be taken to ensure that the use of cameras is within the supplier's policies and does not record any processes which may be proprietary.

During the inspection process, should any unusual issues arise; the inspectors should have a direct line to the client's engineers to resolve these issues in a timely manner to minimize any negative impacts to the project. Depending on the project, the inspectors may or may not be provided with the authority to stop the supplier's production line while these issues are being resolved. The ability to stop the supplier's production line should be seriously considered since the inspectors may unwittingly assume supplier liabilities for delays in production and delivery.

C. Source Inspection Program Management

An effective and efficient source inspection program management is required to ensure that the inspections are done in a timely manner and that all information and reports are being transmitted to the client and stored.

An overall project manager should be assigned to the project. The project manager would report directly to the client's representatives. Weekly status meetings should be held between the project manager and the client's representatives to discuss the source inspection activities for the past week, to discuss any ongoing issues which need client direction and to provide a look ahead as to what inspections will be performed within the next few weeks.

The project manager should have direct control over the inspectors working at the supplier's facilities. In selecting the inspectors, the project manager should select candidate inspectors from a pool of qualified

inspectors and forward the resumes of those candidate inspectors to the client to review and rank. Upon completion of the client's review, the project manager should then select the inspectors based on the ranking provided by the client. Once at the supplier's facility the inspectors should provide daily reports to the project manager. The project manager should edit the daily reports and provide them to the client on a daily basis. Should more than one inspector be required at a supplier's facility, the project manager should appoint a lead inspector. The lead inspector will be responsible for planning and coordinating the inspection activities at the supplier's facility. The inspector should receive and edit the daily inspection reports from each of the inspectors prior to submitting the reports to the project manager.

At the end of each month, the project manager should prepare and submit a monthly report to the client summarizing the inspection activities and issues for that month. The monthly report should be structured such that it can be used as documentation for the monthly invoicing.

The development of an online system would greatly enhance the management of the source inspection program. In most instances, the inspectors, the project manager and the client may be located in different cities and different countries. The establishment of an electronic online system would greatly support the submission and transmittal of the daily reports. In addition the online system could be used as a repository to document, track and store all inspection reports and related correspondences for the project. The client should be provided with access to the online document management system. Notification to the client should be sent out each time a new report is uploaded onto the online system.

5. CHECK LIST FOR STEEL TUBULAR POLES

A. **Materials**: All materials shall meet the ASTM standards as per the customer specs. For coil materials, mechanical test needs to be performed after de-coiling and leveling as per ASTM A6. It is recommended that all materials should be tested in independent lab to verify the accuracy of Material Test Report (MTR) from the vendors.

B. **Base/ Flange Plates**: All thick materials such as base plate of flanges plates shall be thoroughly inspected for any surface defects (visual) as well as any laminar defects (by ultrasonic methods). Most of the thick plates need to be cleaned of mill scale and other potential contaminants by grinding the areas to be welded or blast cleaned before welding with pole shaft.

C. **QA/QC manual**: It is very important to study the details of QA/QC manual furnished by suppliers. This manual establishes the criteria for proper documentation and decisions making in case of rejections due to poor quality.

D. **Weld Procedures Specifications (WPS), Procedure Qualification Record (PQR) and Welder Performance Qualification Records (WPQR's)**: All weld procedures must be qualified in accordance with the requirements of AWS D1.1 and need to be on hand and available for use by the welders and inspectors. Procedure Qualification Records (PQR's), if required, should be made available for review, when requested. All welders also need to be certified as capable in accordance with the requirements of AWS D1.1. Critical Pre-heating and interpass temperatures should be determined per the requirements of AWS D1.1 and properly communicated to all welders.

E. **New Steels**: It is highly likely that AWS D1.1 will require a new welding procedure specification (WPS) and a Procedure Qualification Record (PQR) for any new steel type to be used such as Forged steel or Cast Iron Steels.

F. **Dimensional Check**: It very critical to perform dimensional check for details as per customer approved fabrication drawings.

G. **UT Inspection**: All 100% welds shall be tested with UT to ensure full penetration.

H. **Fittings**: All critical connections including random slip joints fit-up shall be performed at the manufacturing facility to ensure proper fitting according to established tolerance limits.

I. **Galvanizing Venting and Drainage holes**: The cut out holes shall meet the recommended guidelines as per American Galvanizers Associations (AGA).

J. **Process Travelers**: Suppliers shall maintain a record of process at each work station through a proven process tracking travelers System. This report should be available to customers in case of back tracking is required for any investigations.

K. **Rejection Rate**: This report is very critical information for process improvements and measures the productivity levels of personnel at the shop floor.

L. **Post Inspections**: All poles shall be thoroughly inspected for galvanizing coating as per ASTM A123. All welds for base plate and flange plate shall be tested with UT for Post Galvanizing Toe Cracks.

M. **Warranty**: Customers shall request suppliers to furnish warranty certification or a certificate of compliance of finished products.

6. FLOW CHART FOR STEEL POLES MANUFACTURING: (Fig. 2)

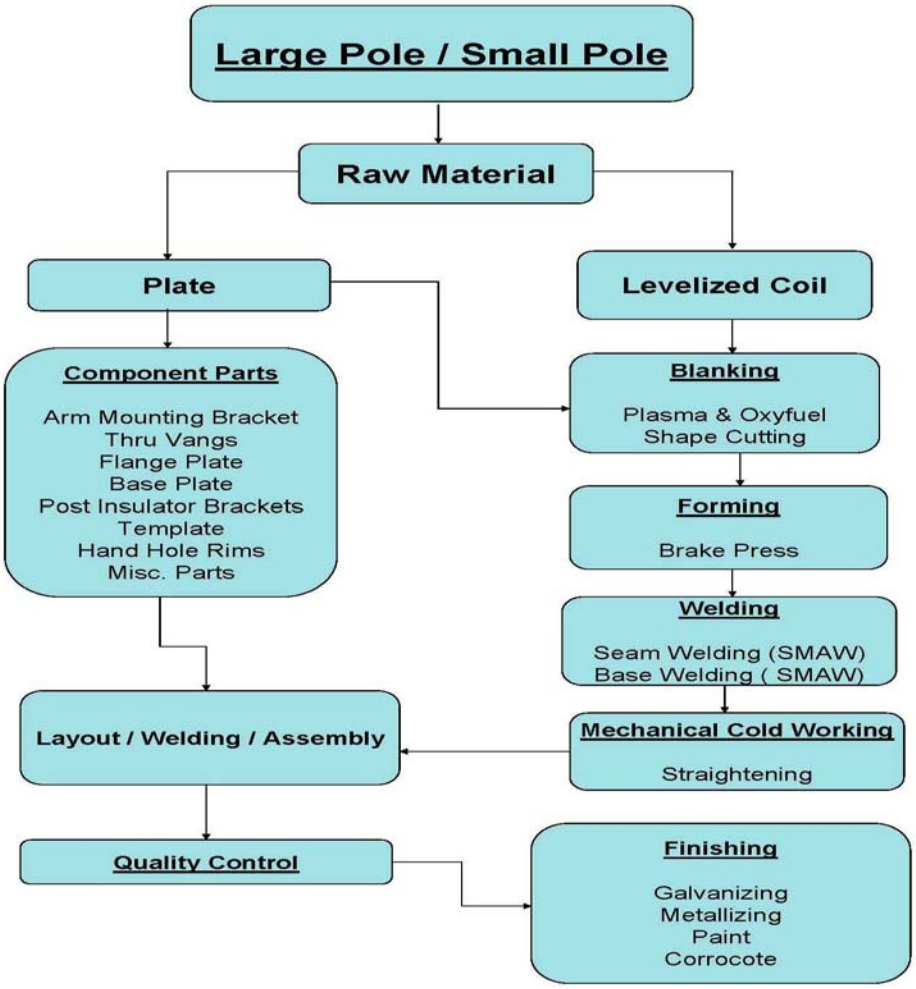

Fig . 2

7. STEEL POLE INSPECTION PROCESS:

Raw Material Inspection: Raw material inspection is required to ensure that only materials that meet the project requirements are used. Any materials that do not meet the specified ASTM requirements, length, width and thickness must be identified and rejected prior to the start of the fabrication process.

Fig . 3: Steel Coils ready for inspection

Fig . 4: Steel Plates ready for inspection

Fig. 5: Steel Coil/Plates ready for inspection

Welding Inspection: Welding inspection is important to ensure that they are in accordance with the applicable ASTM standards.

Fig . 6- Preheating the steel pole base plate

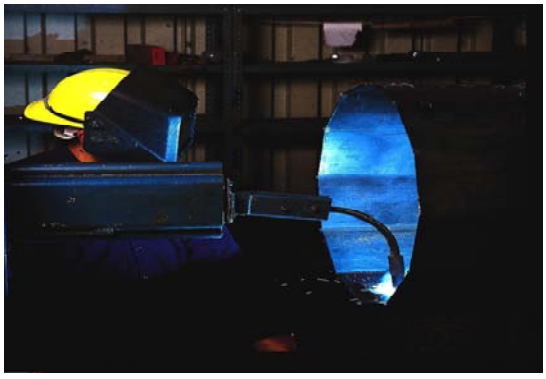

Fig . 7: Seam welding steel pole

Fig . 8 : Welding of Steel Pole Vangs/ Accessories

UT Inspection: UT inspection is performed to assure the integrity of the welded connections.

Fig . 9 : UT Inspection of Seam Weld

Fig . 10 : UT Inspection of Base plate Weld

Fabrication Inspection: To ensure a quality product, the fabrication machines need to be calibrated and re-calibrated periodically. Inspections should check the dimensions and locations of all drilled holes.

Fig . 11 : Inspection of pole weld and repair .

Fig . 12: Inspection of bolt holes & welding

Fig . 13: Inspection of arm brackets

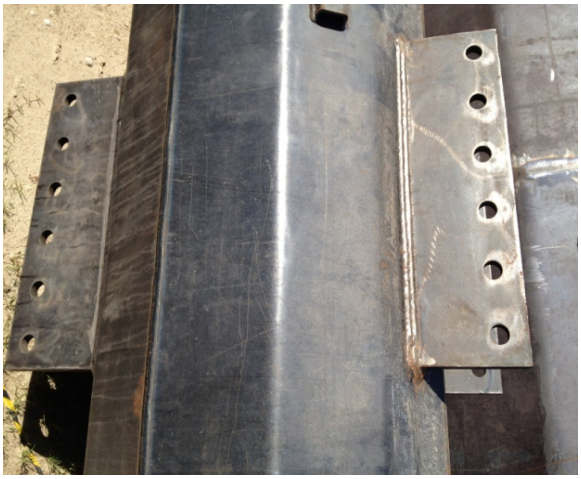

Fig . 14: Inspection of arm vang

Post Galvanizing Inspection: This inspection is required to measure galvanizing coating and Toe Crack check after galvanizing.

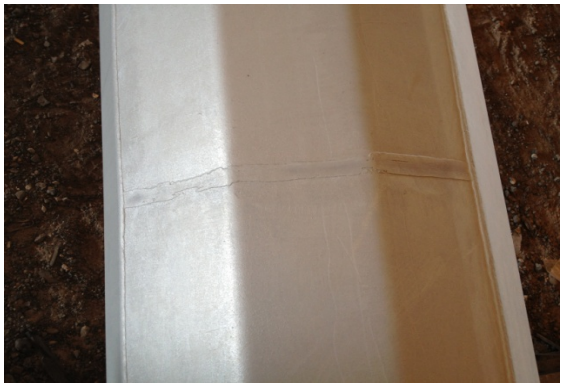

Fig . 15: Galvanized pole surface

Fig . 16: Ready for Toe Crack Inspection

Fig . 17: Pole shaft with Zink kettle

Shipping Inspection: This inspection ensures that coating is not damaged due to poor packaging and movement of shaft material.

Fig . 18: Inspection for proper packaging

Fig . 19: Pole sections on truck.

Fig . 20: Coating damage during shipment

8. CHECK LIST FOR LATTICE STEEL TOWERS:

A. **Raw Material**: All Material shall meet the ASTM standards per customer specs. It is recommended that all materials should be tested in independent lab to verify the accuracy of Material Test Report (MTR) from the vendors.

B. **Fabrication**: All manufacturing work shall be performed in accordance with industry standards and in compliance with all applicable codes along with Customer defined fabrication tolerances.

C. **Proof-of-Fit**: It is also known as full scale prototype. All components of towers shall be assembled in 100% to ensure that members are fitting properly.

D. **Galvanizing**: All materials shall be hot-dip galvanized as per ASTM A123 for angles and shapes and A153 for hardware.

E. **Bundling:** Bundling is a very critical process and requires lots of attentions and experienced manpower. Random check shall be performed to ensure that there are no missing pieces in a bundle.

G**. Shipping**: All components shall be secured either in a box or directly with flat bed to ensure that bundles stay together during transportation. It is not recommended for trans-loading due to high probability of material damages and losing control of bundle identification.

9. FLOW CHART FOR LATTICE STEEL TOWER MANUFACTURING: (Fig # 21)

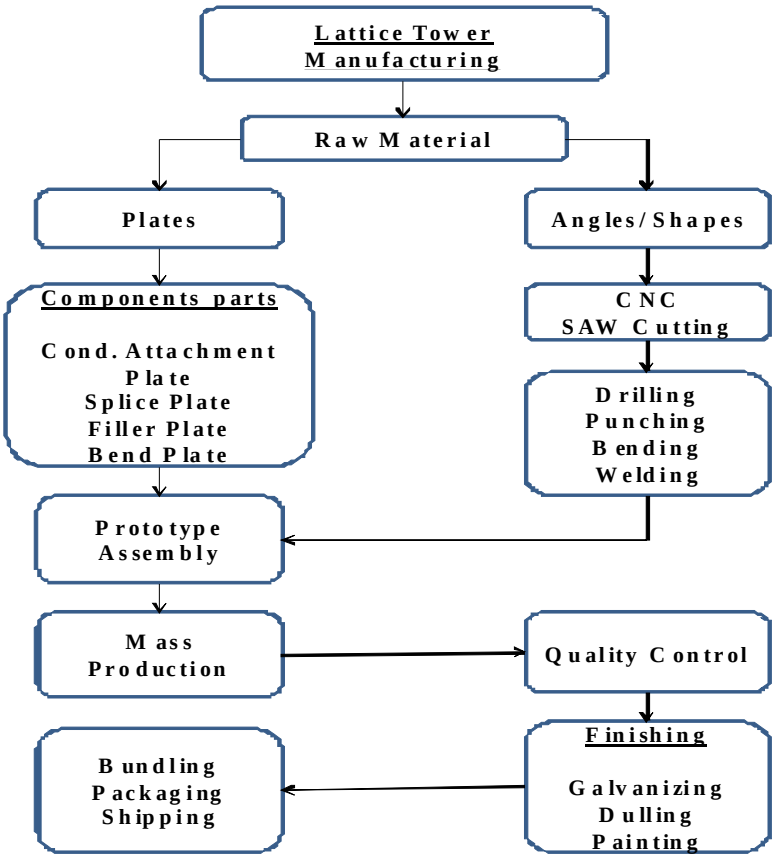

Fig. # 21

10. LATTICE STEEL TOWER INSPECTION PROCESS:

Raw Material Inspection: Raw material inspection ensures that quality steel is used on a project. Any steel profile that does not meet the specified length, width and thickness must be identified and rejected before the start of fabrication.

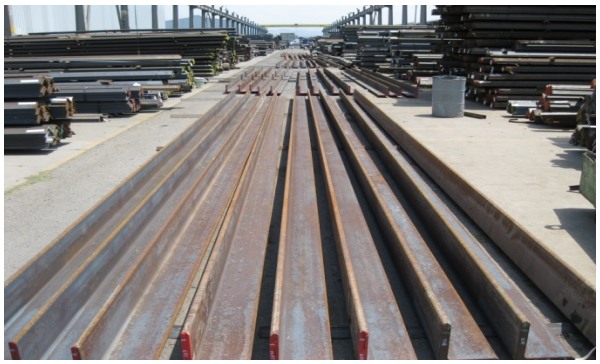

Fig. 22: Raw materials ready for inspection

Fig. 23: Surface flaw found on steel profile

Fabrication Inspection: In fabrication process, CNC machines need to be calibrated and re-calibrated periodically. Fabricated pieces should be randomly selected and checked to verify the accuracy of drilled or punched hole dimensions and locations.

Fig. 24: CNC machine

Fig. 25: Fabricated plates ready for inspection

Proof-of-fit Inspection: Proof-of-fit is an important part of the steel tower fabrication process. Proof-of-fit involves assembling an entire tower prior to the full scale start of fabrication. During this process, assembly conflicts can be identified and resolved. Proof-of-fit ensures that the tower can be assembled at the job site by the contractor without any major fabrication problems.

Fig. 26: Proof-of-fit of tower connection

Fig. 27: Proof-of-fit of upper tower body

Galvanizing Inspection: Galvanizing inspection process includes checking for galvanizing thickness and uniformity after galvanizing.

Fig.28: Measuring thickness of galvanizing

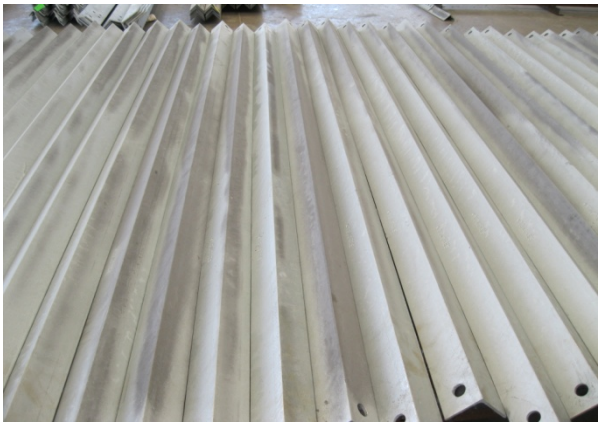

Fig. 29: Checking for galvanizing uniformity

Bundling Inspection: Bundle inspection verifies that all members within a bundle are in accordance with the client's approved bundle list. Bundle inspection should be performed with the supplier's QA/QC personnel and should be done prior to shipment.

Fig. 30: Bundles of plates

Fig.31: Bundles of angles

Delivery Inspection: Shipment inspection verifies that all bundles on the bill of lading are included on the truck.

Fig. 32: Plate bundle ready for shipment

Fig. 33: Angle bundles being shipped by rail

Trans load Inspection: Should the materials need to be trans loaded during the shipment process an inspection at the trans loading point should be performed to monitor and document any damages to the material due to the unloading and loading of materials.

Fig. 34: Materials at trans loading point

Fig. 35: Bundle inspection at trans loading point

11. SAMPLE INSPECTION REPORT RESULTS:

- **Project Name**: Name of the Client's project
- **Project Purchase Order No.**: Purchase order between the Supplier and Client
- **Client's Name**: Name of the Client whom is buying the material
- **Manufacturer & Location**: Name of the Supplier and address
- **Manufacturer Contact**: Supplier's Project Manager's name and phone number
- **Inspection Date & Time**: Date and time of the inspection conducted
- **Description of items Inspected/Expedited**: Inspection category can be raw materials, fabrication, galvanizing, bundling and shipping
- **Summary of Inspections performed**: Point out if anything does not comply with the Client's Specification during raw materials, fabrication, galvanizing, bundling and shipping inspection
- **Concerns & remarks**: Express the concerns and remarks about inspecting raw materials, fabrication, galvanizing, bundling and shipping
- **Attachments**: Take lots of photo and attach them with the report. Also, attach any other documents from the supplier regarding QC and process.
- **Inspected By**: Name of the inspector
- **Date**: Date of the inspection

12. CONCLUSIONS:

Transmission Line Structures such as Steel Poles and Lattice Towers play a very critical role in building robust and reliable transmission infrastructures. These structures are complex in design and require a high degree of skill and experience to properly manufacture and meet the quality standards. Due to orders exceeding current production capacity, many suppliers are having sub-assemblies and components fabricated by 3rd party vendors. Today's fast paced manufacturing world, it is highly recommended that the utility customers should implement source inspection or third part inspection process at the manufacturing plant. Source inspection insures that the suppliers and 3rd party subcontractors are aware of the owner's specification and that the owner's will only accept quality finished products that meet those specifications. There are several key benefits for having the source inspections at the supplier's plant, which ultimately help in mitigating project risk, avoiding the potential impact of financial cost and minimizing the cost of maintenance after warranty period of the finished products.

A well planned and well executed source inspection program is required to ensure that all project materials are fabricated in accordance with industry standards and project requirements. The process of performing source inspections mirrors the process of the life cycle in designing and procuring the structures. The performance of inspections along the entire life of the project ensures that all issues are looked at and that there are "no surprises" in the end. An effective and efficient source inspection program management is required to ensure that the inspections are done in a timely manner and that all information and reports are being transmitted to the client and stored. The development of an online system would greatly enhance the management of the source inspection program.

In this day of mega-projects with very tight deadlines, source inspection is a critical component of any project as material fabrication problems could result in increased project costs. These costs will include the costs of repairing or re-fabricating the part or parts in question and the costs associated with potential project delays. In most instances, the costs associated with any material caused project delays will be large and could be several magnitudes above the cost of the source inspection program. As such, the cost of the source inspection program can easily be justified

13. REFERENCES:

1. SCE Source Inspection Process
2. Burns & McDonnell Project Management Resources
3. ReliaPOLE Inspection Services Company, LLC. (RISC)
4. SANPEC Inc. Source Inspection Process