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<b>QA / QC POLICY AND PROCEDURE</b>		

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## **SUBPART A - PURPOSE**

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It is the policy of Berry Bros. General Contractors, Inc., to strive for the highest quality standards. Quality is the result of careful attention to all phases of our operations. Employees at all levels must work conscientiously to carry out our philosophy and policies to maintain the highest quality possible.

It is the responsibility of all employees to be knowledgeable of Berry Bros. General Contractors, Inc. standards and regulations and to implement all rules, procedures, and regulations contained herein.

This program describes the general requirements for the Quality Control / Quality Assurance (QC/QA) Program, which Berry Bros. General Contractors, Inc. has developed and implemented.

The purpose of these procedures is to document organizational procedures and practices and assure compliance with the applicable codes in order to prevent defects of a structure rather than finding defects after they occur.

It is Berry Bros.' intention to inspect all portions of completed work to insure that the work completed is in accordance to customer specifications and industry standards.


## **SUBPART B - SCOPE**

Berry Bros. will provide qualified personnel to implement the QC/QA program. The QC/QA personnel shall be qualified for the work discipline they are inspecting.

All work not meeting specified quality standards because of defects in workmanship or materials furnished by Berry Bros. will be repaired by Berry Bros.

The following Quality Control Procedures includes the following as a minimum:

- Equipment and materials receipt and inventory.
- Equipment and material storage.
- Dimensional control.
- Material job numbering.
- Wire and electrode identification.
- Welder Identification.
- Preheat and temperature control if needed.

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- Preparation of welding surfaces.
- Welder and weld area weather protection.
- Visual welding inspection.
- Leak testing.
- Preparation of painting surfaces if needed.
- Protective coating application.
- Conservation and cleaning of stored equipment and instrumentation (Preservation).
- Management of changes in processes or procedures.

## **SUBPART C - RESPONSIBILITY**

### ***General Manager***


The Project Manager has the authority and the responsibility to report any non-conformity and/or any non-compliance issues to the appropriate managers and/or administrators and to the client(s) and/or their designated representative(s).

The General Manager shall have the full support and authorization from senior management (i.e.: President) to make any decisions necessary and/or execute a plan of action on any given project. Additionally, the General Manager shall assure that the **compliance manager of the QC/QA program** shall have adequate training and capability to carry out the responsibility effectively. This person shall be free from any conflict of interest in carrying out the requirements of this program. This person shall report on the performance of the Quality System to the General Manager.

**Note:** This report shall include sufficient information to allow continuous improvement of the Quality System.

The General Manager shall report all performance issues of the Quality Control / Quality Assurance to senior management (President) complete with a detailed report. This report will provide material for a data base that will assure continuous improvement of the QC/QA system.

### ***Operation Manager***

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Upon receiving a service request the following steps will take place. A work agreement is written for a specific project by the project manager with a minimum of the following information:


- A specific Berry Bros. job number is issued for the project and recorded on the work agreement.
- The clients' name requesting the project is recorded on the work agreement.
- The customers charge numbers, project numbers, AFE, or any related billing information is recorded on the work agreement.
- The necessary welding procedures required are recorded.
- The necessary coating procedures are recorded.
- The start date and the delivery dates are recorded.
- The delivery destination is recorded.
- A brief description of the project is recorded.
- A carbon copy of the work agreement is secured in the work agreement book managed by the operation manager.

### ***Project Manager***

The project manager receives the original work agreement. Copy's of the work agreement are made by the project manager and distributed to the following departments:

- ACCOUNTING
- SHOP SUPERINTENDENT
- YARD SUPERINTENDENT
- MATERIALS EXPEDITOR
- SHIPPING AND RECEIVING
- HYDRO TECHNICIAN
- PAINT SUPERINTENDENT
- QC/QA SUPERVISOR

A copy of the welding procedures for the specified project is issued to the shop superintendent. A copy of the client's approved drawings and specifications are issued to each department involved in the project by the project manager. A

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separate file will be compiled for the client by the project manager. The project manager will be in charge of ordering all materials for the project.

***Purchasing / Project Manager***

Pursuant to a project being awarded to Berry Bros. General Contractors, Inc. all material(s) are reviewed from the MTO (Material Take-Off) list to insure that all clients' specifications are met.

The Vendors and Subcontractors (if applicable) for the project are then selected using the following procedures and criteria:


- Competitive pricing.
- Approved vendor(s) and/or subcontractor(s) for the customer's best interest.
- Competitive delivery.
- Past performance and established capabilities.
- Assurance that all Client specifications are met.
- Subject to the dynamics and/or critical nature of the given product(s) and/or services of the project, all will be in compliance with the specifications.

Purchasing will then contact the Client to verify if the material(s) and/or the Subcontractor(s) will be billed directly to the Client or put on a Berry Bros.' Purchase Order and re-billed with a moderate mark-up (in keeping with industry standards.)

**In the event that the Client determines that the material(s) and/or subcontractor(s) are "Direct Billed", an order will then be placed with the Client's approved material(s) and/or contractor(s).**

Berry Bros. will insure that the vendor is given a copy of the Clients' specifications and a material list for all items ordered. A copy of the order will also be given to all appropriate departments in order that they are made aware of where the items and/or subcontractor(s) will be coming from as well as the delivery date(s).

Should the Client elect that the order be placed on a Berry Bros.' Purchase Order instead of a "Direct Billing", the same procedure will apply as in the aforementioned "Direct Billing" option

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### ***Shipping and Receiving Manager***

All material arriving at Berry Bros. or the job site will be inventoried. All material will be marked with a Berry Bros. job number by the material expeditor. Pipe and structural materials will be marked with heat numbers from accompanying material test reports. Deliveries that have unreadable heat numbers shall be reviewed by the client or the client's representative(s) for approval and acceptance. The shipping and receiving supervisor will maintain a file in the shipping and receiving office with a copy of all delivery tickets, mill test reports, and any information concerning the projects headed with the company name and Berry Bros. job number. This information can be issued to all involved departments. The QC/QA manager will inspect the aforementioned procedures and report any abnormal findings to the general manager of Berry Bros. Any adjustments necessary, will be implemented and directed to the appropriate department.

Load out and shipping will be organized by the shipping and receiving superintendent. All materials including those shipped will be re-inventoried and documented on a shipping manifest ticket. This ticket will be shipped with the materials. This will insure that the job is complete and accounted for.


Shipment to specific docks or locations will be organized by the shipping and receiving manager.

### **Fabrication Operations**

Upon completion of the materials check-in, the yard superintendent will inform the shop superintendent when the materials are ready to be moved to the fabrication shop or to the barge.

The yard foreman will direct the yard crew where to move the materials as per the request of the project manager.

The shop superintendent will indicate to the yard superintendent and the expeditor what materials are to be tagged and sent to the blasting and painting area if needed.

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It will be the responsibility of the shop superintendent to see that all fabricated items are tagged. The tags will be stamped with job numbers, company, locations, drawing numbers, and piece numbers. The tags will be attached to the fabricated items. Materials not requiring fabrication, such as bolts, hardware, stainless steel items or specialty items, will be tagged, bagged, and stored by the material expeditor. The material expeditor will assist in tagging ship loose items.

The shop superintendent will insure that approved for construction drawings are marked with piece numbers for tagging components in the fabrication shop as well as ship loose items.

The shop superintendent will review all material for proper grade and identification before fabrication begins.

All involved departments will have access to the pre-marked drawings from the shop superintendent.


During the shop fabrication procedures, the shop superintendent will insure that all welders have a copy of the welding procedure list. A copy of the procedure list will be posted in their work stations. This list will include the procedure number, type of weld process, grade of materials, type and grade of the filler metals to be used in the work process.

No welding by a welder shall be performed until he satisfactorily passes the appropriate test when welding in accordance with the qualified welding specifications of Berry Bros.

The shop superintendent will review drawings for proper identification of heat numbers, welder stencil, and NDT numbers as required.

The shop superintendent will indicate where the items will be moved to. The indication will be a spray paint color system that determines, x-ray, hydro-test area or paint area.

At any given time during the fabrication procedures, the operation manager, project manager or general manager may interrupt with specific requests from the client.

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The QA/QC manager will inspect the aforementioned procedures and report any abnormal findings to the general manager.

### **Yard Operations after Shop Fabrication**

When the fabricated items in the weld shop are ready to be moved to x-ray, the yard foreman will obtain the necessary drawings and check with the shop superintendent to insure all the parts are sent or moved. The same procedure will be implemented for materials being moved to the hydro-test or staging area.

The NDT company representatives will notify the Berry Bros. shop superintendent when their operations are completed. Any repair work will be conducted through the shop superintendent. After NDT has been completed and cleared, the shop superintendent will notify the yard foreman. It will be the responsibility of the yard foreman to see that the entire necessary pipe spools that need to be hydro tested is moved to the hydro testing area. Drawings will be used to verify that all pieces are accounted for.

When materials are in the hydro testing area, the hydro technician will insure all pieces are accounted for by using the piece marked drawings issued to him by the shop superintendent. In the event if tags are required to be removed, the hydro technician will be required to replace them after the testing is completed.


### **Paint Operations**

When hydro testing is completed, the hydro testing technician will organize the movement of the materials with the paint superintendent and the yard foreman. The paint superintendent will organize the placement of the materials in the blast and paint area. It will be the responsibility of the paint superintendent to inventory all of the materials by using the pre-marked piece drawings.

The paint superintendent will be required to have knowledge of the clients' painting and coating specifications.

The paint superintendent will be responsible for ordering the required paint and sand for each project.



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The paint superintendent will be responsible for checking the humidity with a swing ohmmeter daily, check the anchor profile after each sand blasting with a TESTEX meter, the paint mills on each coat of paint applied with an automatic magnetic micro tech gauge that is calibrated yearly.

When the materials are completely painted or coated as per the customer's requirements, the paint superintendent, will organize the movement of the materials to a staging area or a load out area with the yard foreman or shipping and receiving managers.

### Senior Project & QA/QC Manager


The Senior Project & QC/QA Manager will deem the responsibility to inspect each stage of the operations from start to finish. The QC/QA Manager will insure that each stage of the project is fabricated and to the latest standards/codes and clients' specifications. Any actions that are incorrect will be reported to the general manager immediately. Corrective actions will be implemented by the general manager to the perspective department.

## SUBPART D - QUALITY MANAGEMENT SYSTEM

### General Requirements

Berry Bros. shall establish, document, implement and maintain a quality management system and continually improve its effectiveness in accordance with the requirements of this International Standard. Berry Bros. will:

- Identify the processes needed for the quality management system and their application throughout the organization.
- Determine the sequence and interaction of these processes.
- Determine criteria and methods needed to ensure that both the operation and control of these processes are effective.
- Ensure the availability of resources and information necessary to support the operation and monitoring of these processes.
- Monitor, measure, and analyses these processes.
- Implement actions necessary to achieve planned results and continual improvement of these processes.

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These processes shall be managed by Berry Bros. in accordance with the requirements of this International Standard. Where Berry Bros. chooses to outsource any process that affects the product conformity with requirements, Berry Bros. will ensure control over such processes. Control of such outsourced processes shall be identified within the quality management system.

**NOTE:** Processes needed for the quality management system referred to above should include processes for management activities, provision of resources, product realization and measurement.

## **SUBPART E - DOCUMENTATION REQUIREMENTS**

### **General**

The quality management system documentation shall include:


- Documented statements of a quality policy and quality objectives.
- A quality manual.
- Documented procedures required by this International Standard.
- Documents needed by Crown Oilfield Services to ensure the effective planning, operation and control of its processes, and Records required by this International Standard (See 4.2.4)

**NOTE:** Where the term “documented procedure” appears within this International Standard, this means that the procedure is established, documented, implemented and maintained.

**NOTE 2:** The extent of the quality management system documentation can differ from one organization to another due to

- The size of organization and type of activities,
- The complexity of processes and their interactions, and
- The competence of personnel.

**NOTE 3:** The documentation can be in any form or type of medium.

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## Quality Manual

Crown Oilfield Services shall establish and maintain a quality manual that includes:

- The scope of the quality management system, including details of and justification for any exclusions.
- The documented procedures established for the quality management system, or reference to them.
- A description of the interaction between the processes of the quality management system.

## Control of Documents


Documents required by the quality management system shall be controlled. Records are a special type of document and shall be controlled accordingly.

A documented procedure shall be established to define the controls needed:

- To approve documents for adequacy prior to issue.
- To review and update as necessary and re-approve documents.
- To ensure that changes and the current revision status of documents are identified.
- To ensure that relevant versions of applicable documents are available at points of use.
- To ensure that documents remain legible and readily identifiable,
- To ensure that documents of external origin are identified and their distribution controlled.
- To prevent the unintended use of obsolete documents, and to apply suitable identification to them if they are retained for any purpose.

## Control of Records

Records shall be established and maintained to provide evidence of conformity to requirements and of the effective operation of the quality management system. Records shall remain legible, readily identifiable and retrievable. A documented procedure shall be established to define the controls needed for

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the identification, storage, protection, retrieval, retention time and disposition of records.

### **SUBPART F - INSPECTION**

Berry Bros. General Contractors, Inc. will provide an in house inspection by Berry Bros.' QC/QA personnel.

### **SUBPART G - STRUCTURAL MATERIAL TRACKING AND DOCUMENTATION**

Berry Bros. General Contractors, Inc. will establish a system, subject to customer's approval, for tracking all project dedicated structural material that is eventually fabricated into the final product. It shall be the responsibility of Berry Bros. to establish the Material Tracking System and operate it on a continuous basis throughout the fabrication of the structure.

Stairway material, handrails, grating, grating supports and deck curbing shall not require full tracking. With Customer's approval, secondary bracing and support members shall not require full tracking.


Berry Bros. will mark all material as soon as it is received in the yard. Sections up to twenty feet in length shall be marked at both ends. In addition, sections over twenty feet long shall be marked at the center. All marking shall be at least six inches from the end.

All structural material shall be stored above the ground on either platform type skids or other similar approved supports.

#### **Tracking**

Pieces, which are fabricated from plate, such as pad-eyes and rolled tubulars, shall have heat numbers and job numbers.

#### **Mill Certificates**

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Berry Bros. will furnish one certified original mill certificate for all pipe, structural shapes and plate for integration into the tracking system of the materials documentation section. Mill certificates shall include chemical analysis, mechanical and nondestructive examinations and shall be identified by heat number, plate number, and mill certificate number.

### **Final Drawings**

If it is requested, Berry Bros. will supply a final drawing, which indicates the heat number or plate number and piece length for each piece assembled into the structure.

## **SUBPART H - PIPE, FITTINGS, AND VALVES DOCUMENTATION**

Tracking of all piping components will not be required, but Berry Bros. will obtain and keep complete records of all mill certificates for all components. Crown shall submit to the customer the mill certification for major components such as pipes, valves, fittings, etc.


The customer has the right to inspect any mill certificates and materials at anytime.

## **SUBPART I - DIMENSIONAL CONTROL**

Berry Bros. will conduct a dimensional control program to insure that all work is performed in accordance with the dimensional tolerance specified in the project specifications.

Berry Bros. will inform the customer representative of dimensional checks for the purpose of scheduling the customer's witnessing of Berry Bros.' dimensional checks.

The fabrication shall proceed on flat and level surface. All offshore interface locations such as structure legs, pump caissons, risers, etc. shall be checked periodically. A final dimensional survey and report of these items shall be performed within one week of a load-out. The "as-built" drawings shall be those drawings supplied by the customer and corrected by Berry Bros. to reflect the actual fabricated state of the work.

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## **SUBPART J - DRAWING AND SPECIFICATION CONTROL**

The design specifications, and drawings shall be furnished by the customer.

All drawings and drawing revisions or changes made by the customer shall be issued and managed only by the Senior Project Manager of Berry Bros. Whenever a revision is issued, the Senior Project Manager of Berry Bros. shall see that all obsolete drawings are destroyed and the drawings with the revisions or changes are communicated to all affected persons. It is the responsibility of the Senior Project Manager to ensure that only approved drawings are used in fabrication.

Upon completion of the project, if the company requests, one “as-built” set of drawings will be supplied to the owner reflecting the actual fabricated state of the work.

## **SUBPART K - MATERIAL RECEIVING**


Shipping and Receiving shall have a copy of each purchase order and receiving ticket.

All accepted materials shall be marked with a job number for identification, or it shall be marked by the customer according to the material tracking control procedures.

All material receiving reports shall be made available to the customer’s engineers upon request. A separate file will be maintained for the customer inspector.

All materials received will be examined for compliance with mill test reports, dimensions, general condition, and quality.

Materials not meeting requirements will be rejected by the shipping/receiving and QC/QA and placed in a staging area and the customer’s engineers informed of the rejection. All materials requiring mill test reports will not be received without complete documentation unless authorized by the customer’s engineering department.

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A copy of all mill test reports shall be maintained in Shipping and Receiving by project number when required by project specifications and the Project Engineer. These files will be maintained as long as the material or any portion of the material is in Berry Bros.' yard.

## **SUBPART L - NON-CONFORMITIES**

Material shall be considered non-conforming when the following conditions exist:

- It is not properly identified.
- No mill test reports when required.
- Specifications are not in accordance with purchase orders.
- Material does not meet applicable code requirements.
- The product life or shelf life has expired.
- Errors in fabrication or welding.
- Errors in blasting and painting.


Materials not conforming to approved drawings, specifications, or applicable code requirements shall be tagged "REJECT" and placed in a staging area and the customer's engineering department is informed of the problem and they will decide to accept or reject the non-conformities.

## **SUBPART M - WELDER PERFORMANCE REQUIREMENTS**

All welders and welding operators shall be given a welder performance qualification test by Berry Bros. in accordance with the applicable codes.

No welder shall perform any welding until he has satisfactorily passed the appropriate test when welding in accordance with the qualified welding procedure specifications of Berry Bros.

The operations manager or independent laboratory supervises the testing of welders. The individual supervising the testing signs welder qualification records and then the certifications are made available to the Engineer.

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No welder shall be given a re-test until he has demonstrated to Berry Bros. that he has had additional practice and training.

A welder satisfactorily passing a performance qualification may be disqualified by operations manager or customer's inspection when performing unacceptable quality work.

Welders will be re-qualified or terminated when:

- Performing unsatisfactory work
- When not welding for three to six months depending on the area of qualification. This period may be extended to one year.
- A change in performance variation occurs.

## **SUBPART N - WELD FILLER MATERIAL CONTROL**

For the purpose of quality control, weld filler material shall consist of rod, wire, flux, and electrodes.

Weld filler material used shall be in accordance with a qualified welding procedure specification.

All weld filler material shall be checked at the time of delivery for compliance with the purchase order and identification by the quality control inspector.


Filler material shall be kept dry in shipping containers until ready for use and stored in a dry place.

Electrodes will be purchased in moisture proof containers. When shipping containers are opened, the electrodes shall be kept in a rod oven at a controlled temperature as per manufacturing's recommendations.

When low hydrogen rods are used the welder will check out a 10# rod oven from the tool room to keep the rods in by his work station.

## **NDT (NON-DESTRUCTIVE TESTING)**



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NDT will be performed by a third party vendor that is approved of by the customer.

## **SUBPART O - STANDARD PROCEDURES FOR QUOTATIONS**

### **Receiving an RFQ**

Upon receipt of an e-mailed RFQ:

- Print all documents. (If you are unable to print them, get someone else to print them for you)
- Assign RFQ a bid number and log it in.

Upon receipt of any other RFQ:

- Assign RFQ a bid number and log it in.

Assigning a bid number:

- Open the "Bid Log" to the first empty row available.
- Assign the next bid number to your RFQ.
- The first part of the bid number is the month in which you open the bid.
- The second part of the bid number is the next larger number than on the previous row.
- The third number is the last two digits of the year in which you open the bid.

Login the bid on the "Bid Log" in Excel, in the computer.


Make a bid folder for the bid:

- Write the Company name, description, bid number and due date on the bid folder tab.
- Put bid information such as faxes, vendor pricing, bid work-up, bid letter and RFQ documents in the folder.

Check to see if you have received all drawings and documents:

- If a list of contents is included in the bid, use it as a checklist.

Make a copy of any drawings included in the RFQ documents:

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- Make a copy of the drawings, so that you can make mark-ups without doing so on the originals.

Read the Scope Of Work and/or Instructions to Bidders:

- If the bid includes a scope of work, read it and take reference notes.

Do takeoffs and send out for pricing:

- Do a takeoff of the items that will take the longest to price first. Examples: valves, instruments, machine shop fabricated items. (All material and items are sent to at least three vendors unless otherwise specified)
- Send out for pricing on the “long lead” items, before continuing with the rest of your takeoff.
- When pricing valves, instruments or special items, provide company specifications, data sheets or special instructions with the takeoff.
- Do a takeoff of the remainder of the project.
- Send out for pricing on the remainder of the items. Be sure to specify the Company approved countries of origin for the material.
- Send out for pricing on any third party services required.

Calculate labor cost:

- If doing bid with piping, do a weld-count. (It may be easier to do the weld count as you are doing your material take-off).
- Adjust the multipliers for the structural, paint, shipping & receiving, etc., if necessary.

Enter costs in bid:


- Determine which pricing you will use by discussing vendor product quality and deliveries and decide upon best interest of customer and enter it in the appropriate place in the bid spreadsheets.

Determine delivery:

- Using material deliveries, third party contractor’s deliveries, workload, estimated man-hours and consultation with Randy and/or Jack determine how long the project will take to complete.

Review the bid with General Manager:

- Consult with Randy on shop workload, cost per man-hour, and relationship with customer, etc.

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Write a bid letter:

- Write a bid letter in "WORD". Provide pricing, delivery, weight, etc.
- Clarify materials used, origin of material, what is provided for, etc.

Fill-out Bid Form:

- If you receive a bid form with the RFQ, make copies of it. Write on one and have someone type on the other copy.

Send in the proposal:

- Send the bid letter, the customer bid form (if applicable), material lists (if applicable), schedule (if applicable), etc. to customer.

Fill-in the bid log:

- Put the price, date bid and delivery given in the Excel bid log.
- File the bid folder in the file drawer.

## **SUBPART P - ELECTRONIC CALIBRATION PROCEDURE #200**

### **Purpose**


This Procedure number 200 outlines the requirements and procedures for the calibration of welding machine volt and amp meters, and overall inspection of welding machine.

### **Scope**

This procedure applies to the calibration of the voltmeter and amp meters on welding machines in meeting crown oilfield services requirements.

### **Procedure**

Perform Operational Checks

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- Check for meter reading with input terminals of meter shorted together.
- Check for free movement PF meter point from zero to full scale and returning to zero.

Maintenance personnel shall perform calibration as well as general maintenance to welding machines as part of this procedure.

### **SUBPART Q - HYDRO TESTING PROCEDURE**

The following guideline provides a basic standard for Hydrostatic Testing Procedures at BBGCI. It is the intention of BBGCI Management to provide a safe environment and to comply with all safety regulatory requirements.

Hydro-test procedures may be revised, pending management; however, no safety standard or rule shall be changed or otherwise performed indifferent.

### **SUBPART R - SAFETY REQUIREMENTS**

All steps shall be discussed and listed on a JSA prior to startup of any Hydro Test Procedure.

Personal protective equipment shall be used or worn at all times. Special emphasis is implied concerning safety glasses, gloves, steel toe boots, hard hats, and fall protection.

Caution shall be addressed when assembly and rigging techniques are in progress.

- When cranes or cherry pickers are used, the alertness and responsive actions of the operator shall be implied.
- Tag lines will be used to move materials in overhead lifting.
- Swinging hammers and holding back-up wrenches shall be performed with caution.
- When using pneumatic impact wrenches, insure that safety pins are inserted at all hose connections. Socket retainer pins shall be used on all socket connections.
- When working at heights, special attention should be given to work surfaces to allow for only approved methods.



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A “CAUTION” barrier shall isolate the hydro-area. The hydro-operator and qualified persons shall remain inside the barrier for test procedures.

While hydro-test is in progress, no part of the system will be tightened or loosened.

Field Safety Analysis Checklist shall be performed before all hydro tests.

Homemade blind flanges or pre-fabricated blinds shall not be used for hydro-testing. Only ANSI qualified blinds or weld connections shall be used.

## **SUBPART S - GENERAL REQUIREMENTS**

A detailed JSA shall be prepared and discussed with all authorized persons involved in each hydro-test.

All piping to be hydro-tested shall have passed radiographic inspection (ANSI B 31.1 code).


Visual inspection shall be required to check for impact damage that might occur during movement of materials from x-ray area to hydro-test area.

All materials shall be checked to insure the “piping design” is rated for the required hydro-test specification.

An equipment inspection shall be recorded to insure the following:

- Correct pressure recorders
- Correct chart and chart recorders
- Series numbers on equipment match certificates
- Equipment calibration certificates shall be up to date and on job site (hydro area).

A pre-safety analysis shall be required to determine minimum and maximum pressure ratings resulting from weather conditions such as temperature variations and material burst pressure. A pre-planned pressure step-up shall be implemented holding for a minimum of 5 minutes to check for leaks in flange connections or equipment connections before reaching required test pressure.

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Set-ups may be required 3 or 4 times depending on maximum test pressure required.

Hydro-test documentation shall be recorded prior and during testing operations by one qualified person, that person being designated by Berry Bros.' Management to be the operator, who by reason of experience and instruction is deemed competent to perform the operations required. The hydro-test operator shall address Berry Bros.' Management and/or customer representative with any, and all, problems or questions on hydro procedures.

A typed form containing all field test reports and the original recorded chart may be mailed or delivered to customer representatives upon request.

## **SUBPART T - SET-UP**

Complete a JSA and review with all personnel involved in the hydro test.

Piping spools shall be set-up with a low point fill and a high point vent. Placement of such outlets will be assigned by the operator.

Bolting together low pressure rated flanges using flextallic gaskets.

- End wrenches and hammer wrenches can be used to tighten flanged connections.
- Pneumatic wrenches may be used to utilize time. Caution shall be addressed to not damage flextallic gaskets.

Bolting together high pressure rated flanges (ring-type joints).

- Tighten flanges, first using hand wrenches to insure an even make-up.
- Pneumatic impact wrench will be used for second round of bolt make-up.
- A third or fourth round with impact wrench will be used or until desired torque is obtained.



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Bolt-up procedure will be followed by manufacture depending on size and rating of flange connections.

- Clean all flange faces and ring grooves.
- Solvents may be used to wipe clean gasket area or ring grooves.
- Wire brushing may be used to clean gasket area or ring grooves.
- Caution shall be addressed to not damage gasket area or ring grooves.

ANSI or API rated blind flanges will be placed and bolted on each end of pipe spool(s) to contain water in piping. Welded caps will be used where applicable.

Connect the test pump to the pipe spool using a 10,000 PSI test head valve assembly.

Connect a 10,000 PSI needle valve on high point vent. Valve must remain in open position.

Connect the pressure recorder to the test head valve.

Connect the temperature recorder or temperature probe thermocouple into the piping. Duct tape may be used to connect the probe to the side of piping.

A more common test recorder is equipped with a dual pen. This means the recorder will be able to record pressure and temperature on one chart deeming it a dual pen recorder.

Connect a clean water supply line to the hydro-pump. Water should be off at this time.

At times a more practical solution to fill a large volume with water is to hook the water hose directly to the pipe. This will minimize filling time. When the piping is full, the water line will be turned off and disconnected from the piping, the water line will be re-connected to the hydro-pump.

Connect air supply to hydro-pump. Insure that safety pins are at each hose connection. Do not turn air supply on.



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At this time, all connections should have been made. The hydro-operator will direct to have a barrier put in place. This barrier will be a safety flagging containing the word "CAUTION" written simultaneously on the entire length of flagging. This flagging indicates the hydro pressuring is about to begin or is in progress. All unqualified personnel shall leave this area and not re-enter without the consent of the operator.

At this time, wind up the timing mechanism on the recorder and place the appropriate chart in place. Set chart on correct time of day.

Turn on water line and begin filling to remove trapped air in system.

Turn on air supply to hydro-pump. Begin pumping at very slow rate.

Close all high point vents. At this time there will be an increase of pressure.

Carefully pump up to first pre-planned pressure rating and stop pump. Close off main valve on test header.

Check for leaks around flange connection and threaded connections. Hold pressure for 5 minutes minimum and continue to check for leaks.


If no leaks are found, open main valve on test header and continue to pump to increase to the next pre-planned pressure rating.

When leaks are adopted, all pressure must be released to "0" PSI. Repair leaks by retightening bolts or replacing failed components.

A new chart is not required at this time unless customer rejects the condition of the present chart.

Re-start hydro test starting at "0" PSI. Repeat the pre-planned pressure steps until desired test pressure is acquired. Test pressure will be held for the period of time as pre-planned by the designed engineer. Usually, a one hour minimum, after desired PSI is achieved.



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When weather conditions induce a rise in temperature, usually the test pressure will rise on its own. Bleeding off pressure will be allowed to prevent over pressuring of the materials.

In most cases, materials should not be hydro-tested more than one and one-half (1 ½) times the maximum allowable working pressure of the designed materials.

When a decrease in pressure occurs below established pressure requirements, due to falling temperature or other reasons, the test becomes void and a new test must be established with a new chart. Pumping up after the established pressure rating occurs is not permitted.

When the established pressure requirements are reached and clearly noted on chart, the test header valve is turned off along with the hydro pump and air supply. When the desired time length is reached and clearly noted on the chart, the pressure is released and the piping is dismantled.

Documentation shall be drafted during the hydro-test indicating the time and pressure and temperature changes. All pertinent information concerning equipment certification and calibrations shall be drafted on this document. This document may be signed as a witness by customer representative or by Berry Bros.' Management.


## **SUBPART U - SPECIAL APPLICATIONS**

The use of digital or hydraulic deadweight indicators are generally not used in Crown hydro-procedures. However, they can be implemented upon the request of the customers.

The use of corrosion inhibitors is not used on low volume or short time frame test. If inhibitors are implemented the disposal of the contaminated water shall be the responsibility of the customer.

Hydrostatic testing requiring more than 10,000 PSI shall not be performed by Berry Bros. personnel. A third party vendor will be contacted to perform such operations.

Any special applications or procedures shall be addressed and agreed upon before any hydro testing is performed in the pre-safety and job scope analysis.

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## **SUBPART V - HYDRO-TESTING EQUIPMENT**

An air operated positive displacement pump shall be used with a 10,000 PSI operating range.

A 10,000 PSI test manifold shall be connected on spool pipe low point fill inlet. The test manifold shall be constructed with ½ inch XXH rated pipe with 10,000 PSI needle valves to isolate the pump from actual test pressure. Down stream of the isolation valve, an outlet shall be provided to connect test recorders.

All test pump hoses and test recorder hoses shall be 10,000 PSI capacity with matching connections.

Barton test recorders or recorders with the same quality shall be used. Pressure range on recorders depends on the required procedure. The recorders shall be re-calibrated annually.

## **SUBPART W – FIELD SAFETY ANALYSIS / FIELD SET UP CHECK LISTS**

### **FIELD SAFETY ANALYSIS CHECK LIST**

**Job Number** \_\_\_\_\_

1. \_\_\_\_\_ Completed JSA listing each task with a description.
2. \_\_\_\_\_ Materials have passed x-ray inspection
3. \_\_\_\_\_ Visual inspection for material damage
4. \_\_\_\_\_ Required hydro pressure
5. \_\_\_\_\_ Required hydro pump
6. \_\_\_\_\_ Recorder pressure range
7. \_\_\_\_\_ Digital dead weight, all pressure hoses & jumpers are in good condition.
8. \_\_\_\_\_ No welding on pipe for field welds while hoses, valves, chart recorders are on line.
9. \_\_\_\_\_ All unauthorized personnel stay at least 15-35 feet away from test while test(s) are conducted
10. \_\_\_\_\_ Recorder calibration date
11. \_\_\_\_\_ Recorder serial number
12. \_\_\_\_\_ Chart pressure range
13. \_\_\_\_\_ Equipment certificates on job site
14. \_\_\_\_\_ Flanges have been stress relieved
15. \_\_\_\_\_ Certificates match equipment




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16. \_\_\_\_ First pre-planned pressure step-up
17. \_\_\_\_ Second pre-planned pressure step-up
18. \_\_\_\_ Third pre-planned pressure step-up
19. \_\_\_\_ Fourth pre-planned pressure step-up
20. \_\_\_\_ Maximum allowable pressure
21. \_\_\_\_ Operator initials to verify 1 thru 20 are correct

### **FIELD SET UP CHECK LIST**

1. \_\_\_\_ Adopt a plan to set up spool pipe with a low point fill and a high point vent
2. \_\_\_\_ Collect necessary tools and equipment needed to assemble spool pipe
3. \_\_\_\_ Air hoses are connected with safety pins and hose whip checks
4. \_\_\_\_ Socket retainer pins are installed on socket connections
5. \_\_\_\_ Clean each flange face or ring groove before installing ring gaskets, flex gaskets, and bolts
6. \_\_\_\_ All flange connections are made including end blinds
7. \_\_\_\_ Teflon tape is applied on threaded connections
8. \_\_\_\_ All thread-o-lets have been tapped with thread tap
9. \_\_\_\_ 10,000 PSI test header is connected to pipe spool at low point fill inlet in open position
10. \_\_\_\_ 10,000 PSI needle valve is connected to high point vent outlet in open position
11. \_\_\_\_ Connect pressure recorder to test header
12. \_\_\_\_ Connect thermocouple to piping
13. \_\_\_\_ All flanged and threaded connections have been tighten
14. \_\_\_\_ Piping has been filled with water and water line is connected to hydro pump
15. \_\_\_\_ Air line is connected to hydro pump
16. \_\_\_\_ Caution flagging is put in place
17. \_\_\_\_ Recorder timing mechanism is activated and chart is installed on correct time of day
18. \_\_\_\_ Turn on water supply to remove trapped air
19. \_\_\_\_ Turn on air supply to pump, beginning with slow pumping rate
20. \_\_\_\_ Close high point vents
21. \_\_\_\_ Pump to first pre-planned pressure rate and close off main valve on test header and stop pump

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22. \_\_\_\_ Check for leaks on flange connections and threaded connections. Hold for 5 minute minimum
23. \_\_\_\_ All pre-planned pressure step-ups have been performed
24. \_\_\_\_ Desired pressure requirements and time length have been established
25. \_\_\_\_ All pressure has been released to "0" PSI
26. \_\_\_\_ Pipe spools are dismantled and ready to be moved to paint area


## **SUBPART X - BLASTING AND PAINTING**

### **Quality**

- The coating applicator is responsible for insuring that each coat has been applied on a properly prepared surface using materials, techniques, and equipment that are in compliance with this specification as well as the coating materials and spray equipment manufacturer's recommendations.
- Wet and dry film gauges, inspection tools used to determine surface profile of blast-cleaned surfaces, and all other test equipment shall be calibrated. Dry film measurements shall be done in accordance with ASTM D1188.
- Coating systems shall be free from blisters, cracks, holidays, or other injurious defects. Minor runs, drips, or other defects that are clearly cosmetic in nature must be reviewed by the company for acceptance.
- Defects shall be repaired as per manufacturer's specification or company specification.

### **Solvent Cleaning**

Prior to abrasive cleaning of steel substrates, it is imperative to solvent clean for removal of grease and oil. A misconception exists that abrasive cleaning removes grease and oil. In reality, it may remove a fraction of the contaminant but the

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remainder is impinged upon the substrate. To be effective, a solvent cleaning operation must be implemented. Solvent must also be rejuvenated periodically as it becomes saturated with grease and oil.

### **Steam Cleaning**

This method effectively removes heavy deposits of dirt and grime due to a combination of high velocity, high temperature steam. The addition of caustic detergents or cleansers into the water will readily remove greases and oils.

### **Hand Tool Cleaning**


Procedure for removal of loose mill scale, loose rust, and loose paint by hand brushing, hand sanding, hand scraping, hand chipping, or other hand impact tools, or by a combination of the above methods.

### **Power Tool Cleaning**

Procedure for removal of loose mill scale, loose rust, and loose paint with power wire brushes, power impact tools, power grinder, power sanders, or by a combination of the above methods. It is not intended that all mill scale, rust, and paint be removed by this process. However, loose mill scale, rust, paint and other loose detrimental foreign matter will be removed.

### **White metal blast and cleaning**

Procedure for removal of all mill scale, rust, rust scale, paint, or foreign matter by the use of abrasives propelled through nozzles or by centrifugal wheels. Defined as a surface with a gray-white, uniform metallic color, slightly roughened to form a suitable anchor pattern for coatings. The surface when viewed without magnification, shall be free of all oil grease, dirt, visible mill scale, rust, corrosion products, oxides, paint, or and other foreign matter. The color of the clean surface may be affected by the particular abrasive medium used.

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### **Commercial Blast Cleaning**

Procedure for removal of mill scale, rust, rust scale, paint, or foreign matter by the use of abrasives propelled through nozzles or by centrifugal wheels. All oil, grease, dirt, rust scale, and foreign matter shall be completely removed except for slight shadows, streaks, or discoloration caused by rust stain, mill scale oxides or slight, tight residues of paint or coating that may remain. If the surface is pitted, slight residues of rust or paint may be found in the bottom of pits; at least two-thirds of each square inch of surface area shall be free of all visible residues and the remainder shall be limited to the light discoloration, slight staining of tight residues mentioned above.

### **Brush-Off Blast Cleaning**

Procedure for removal of loose mill scale, loose rust and loose paint by the impact of abrasives propelled through nozzles or by centrifugal wheels. All oil, grease, dirt, rust scale, loose mill scale, loose rust and loose paint or coatings shall be removed completely. Tight mill scale and tightly-adhering rust paint and coatings are permitted to remain provided that the entire substrate is exposed to the abrasive blast pattern sufficiently to expose numerous flecks of the underlying metal uniformly distributed over the entire surface.


### **SUBPART Y - INSPECTION**

Surface preparation should be inspected at the time it is being performed. Pictorial standards (NACE, ASTM, and SSPC) or visual standards (NACE, SSPC, and ISO/SIS) may be used.

### **SUBPART Z - SURFACE PROFILE DEPTH**

The surface profile can be defined as the average measurement of the peaks and valleys present on the substrate. There are several ways to measure this depth. Methods used in the field include the following:

- Keane-Tator Surface Profile Comparator
- Roughness Gauge

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- Surface Profile Gauge
- Press-O-Film: permanent record of the profile

## **SUBPART A II - SURFACE PREPARATION – NON-FERROUS METALS**

These metals react or corrode when exposed to normal weathering conditions and form a surface oxide layer. This layer poses a potential adhesion problem for coatings and must be removed. Procedures are as follows:


- **Aluminum:** Solvent clean in accordance with SSPC-SP 1, “Solvent Cleaning.” Brush blast or acid etch with ALUMIPREP 33 to provide an etched surface.
- **Copper:** Solvent clean (SSPC-SP 1). Sand to remove oxides, or treat with METALPREP 79.
- **Galvanized Metal:** Remove all oil, grease, dirt and foreign matter by solvent or detergent cleaning (SSPC-SP1). Treat the surface with GALVAPREP 5 in accordance with the manufacturer’s printed instructions.

## **SUBPART B II - KEYS TO SUCCESSFUL SURFACE PREPARATION**

- All forms of surface contamination, especially oil and moisture, must be eliminated.
- Spent abrasive must be removed by sweeping or blowing down surfaces.
- Remove weld spatter and slivers.
- Keep abrasive clean.
- Apply coatings prior to flash rusting of steel (usually 4 hours or less) after blasting.
- Select abrasive of the proper size and hardness in relation to type of steel being used and surface profile desired.
- Follow all applicable safety standards.

## **SUBPART C II - COATING OF PREPARED SURFACE**

Approximately 85% of all premature coating failures are a result of poor surface preparation, inadequate mixing, thinning, and/or poor coating application. Onsite quality control inspection during surface preparation and coating application procedures can help prevent failures of these types. Proper inspection techniques

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must be combined with knowledgeable instrument use, good common sense, and thorough documentation of work activities and inspection checkpoints to help ensure specification compliance.

### Eleven Points of Blasting and Painting Quality Control

#### Pre-surface Preparation Inspection

- Prior to starting surface preparation and coating work, it is necessary to determine that the structure is ready for surface preparation and painting. Procedure detail for surface preparation is detailed in the SSPC specifications.
- Steel contaminated with soluble salts (i.e. Chlorides and sulfates) develops rust back rapidly at intermediate and high humidity. Therefore, these salts must be removed from the steel surface preferably before blast cleaning and by eliminating sources of recontamination during and after blast cleaning.

#### Ambient Conditions

Measuring ambient conditions entails obtaining an air temperature, surface temperature, percent relative humidity, and dew point temperature. The ambient conditions must be obtained, documented, and compared with the established ranges for compliance with the company specifications. The air temperature, relative humidity, and dew point are determined by instrumentation, including **psychrometers** or instruments that give direct read-out recordings of humidity or dew point. Measurements with these instruments are taken before work begins each day and periodically throughout the day. Dew point is important in coating work because moisture condensation on the surface will cause freshly blast-cleaned steel to rust or a thin, often invisible film of moisture to be trapped between coats that may cause premature coating failure (blistering). The final blast cleaning and coating application, should not take place unless the surface temperature is at least 5 degrees F higher than the dew point temperature. **The date, time of day, location of measurement, and whether or not the work was allowed to commence/continue also should be formally documented.** The **Sling Psychrometer** is the instrument used by Berry Bros. to check the air temperature, relative humidity, and dew point.

#### Compressed Air Cleanliness





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Compressed air used for blast cleaning, blow down, and coating spray atomization must be free from oil and moisture contamination. Contaminants of this type are effectively transferred to the surface with the air and blast-cleaning media (abrasive) or by mixing it with the coating during application. Adequate moisture and oil traps will be used on all lines to ensure that the air is dry and oil free so it does not interfere with the quality of the work. To determine air cleanliness a clean piece of white blotter paper or a white cloth will be held 18" from the air supply, downstream of moisture and oil separators. The air is permitted to blow on the blotter paper for minimum of 1 minute. Then the blotter is inspected for signs of detrimental amounts of moisture or oil contamination. A thorough inspection of the surface after blast cleaning for signs of moisture or oil contamination will be made, and these results will be correlated with the results of the blotter test.

### Measurement of Surface Profile

The twofold purpose of surface preparation is to roughen and clean the surface. The surface profile, anchor pattern or roughness is defined as the maximum average peak-to-valley depth (height) caused by the impact of the abrasive onto the substrate. Both SSPC-SP 5 and -SP 6 can have a surface profile of 1 to 4 mils. Surface profile effectively increases the surface area to which the coatings can adhere, and it provides a mechanical anchor that aids in adhesion. Specifying surface profile is critical, thick coatings require a deeper surface profile than thin coatings.

Surface profile determinations will be made in the field or shop with a spring micrometer. Surface profiles can be determined by using replica tape. The replica tape consists of an emulsion film of microscopic bubbles attached to a uniform, 2-mil film of mylar. The tape is pressed onto the blast-cleaned surface, emulsion side down, and the mylar is rubbed vigorously with a blunt instrument. The peaks of the profile will break the bubbles and ultimately touch, but not alter, the thickness of the mylar, because it is non-compressible. The tape is removed and measured using a lightweight, spring-loaded micrometer that provides a reading from the upper-or outermost surface of the mylar to the high spots on the emulsion which were not totally crushed (corresponding with the valleys of the profile). The total micrometer reading is adjusted for the thickness of the mylar to provide a direct reading of the maximum average profile.

### Surface Cleanliness

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Surfaces shall be prepared for coating in accordance with the SSPC method including the following items:

- Parts shall be coated as soon as possible after surface preparation has been completed. Coating applicator shall make every effort to prevent the contamination of parts after cleaning and prior to coating.
- It is Berry Bros.' responsibility to insure that all sharp edges have been broken, rough welds have been ground to provide a smooth transition with adjacent metal, all weld spatter has been removed, and that any surface defect such as a deep pit or crevice has been removed by a suitable mechanical means prior to sending the assembly to the coating applicator.
- The type and size of abrasive shall be selected such that the optimum surface profile is developed for anchoring the coating. Unless otherwise recommended by the coating manufacturer, blasting shall develop an average, uniformly distributed profile depth of approximately 20-30 percent of the total dry film thickness of the complete system. Profile shall be measured using replica tape in accordance with NACE RP0287.
- Care shall be taken to prevent the contamination of abrasive particles with oil. Sand and flint abrasive shall not be reused.
- Finished machined surfaces such as threads, ring joints, or other surfaces that do not require coating, shall be adequately protected during blasting including a light film of grease to prevent damage. In addition areas such as valves shall be stuff with filter media cloth and masked off during blasting to prevent abrasive particles from entering.
- After blasting, sand, dust, grit, etc., shall be removed by compressed air (clean and dry) or by vacuum cleaner. Parts must be dry prior to coating.
- Blast cleaned parts shall be coated as soon as possible (within 4 hours) after being blasted and before the appearance of any surface rust.
- Cleaned surfaces that become contaminated or show signs of flash rusting shall be reprocessed using the applicable SSPC procedure before being coated.

### **Paint Storage, Mixing, and Thinning Procedures**

- Coating materials shall be stored in accordance with the manufacturer's recommendation.




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- All coating materials and solvents shall be stored in the original container bearing the manufacturer's label and instructions. Each product shall have a batch number showing year and month of manufacture and giving full trace ability of production. Shelf life shall be included in the technical data sheet. If any portion of the coating material in a container shows signs of degradation after storage, the entire contents shall be discarded.
- Limited shelf life coating materials shall be discarded after the coating manufacturer's expiration date marked on the container.
- The contents of each container shall be thoroughly mixed before use following the manufacturer's instructions. Two component systems shall be mixed as required, but no more than what can be used before the pot life is exceeded. Pots shall be agitated, if necessary, to keep the coating materials well mixed. Thinning is permissible only when specified by the coating manufacturer for a given type of applicator. The types and amounts of thinner materials shall be as recommended by the coating manufacturer.
- Unless otherwise specified by the applicable documents, all coating material shall be from the same manufacturer.

### **Application techniques**


- The applicator shall strictly adhere to the coating manufacturer's instructions for application unless otherwise specified by Crown. Particular attention shall be paid to mixing, thinning, pot life, curing, and time intervals between coats.
- Coating may be performed only when the environmental conditions fall within the humidity and temperature constraints recommended by the coating manufacturer. In no case is coating permitted when the temperature is less than 5 degrees F above the dew point. See appendix A.
- Areas that are difficult to spray coat (such as corners, edges, welds, brackets, bolting, etc.) may be pre-coated with a medium bristle brush or medium nap roller prior to spray coating to insure the proper thickness of coating.
- Only clean, dry air shall be used for spraying. Air pressure shall be regulated in accordance with the spray equipment manufacturer's recommendation.
- Spraying equipment shall be thoroughly cleaned before use.
- Spray guns shall be held at approximately a right angle to the surface being sprayed. Each spray pass shall overlap the previous pass by approximately 50%.

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- Applicator shall insure that each coat is applied in a uniform manner and has the correct thickness as specified by manufacturer or company. Runs and sags may be brushed out.
- The applicator shall apply the number of coats specified by the manufacturer or company and insure that the overall thickness of the finished coating system is within the specified range.
- Baking or other means of forced drying is prohibited unless specifically approved by the **Company**.

### Wet and Dry Coating Thickness

- The wet thickness of and applied coating film should be measured to ensure that sufficient dry coating shall be present after solvent evaporation and curing. A wet film thickness gauge can be used to monitor the amount of wet coating applied.
- The basic formula for calculating wet coating thickness is found in the following equation: Wet film thickness = dry film thickness / % solids by volume
- The equation is accurate, if the solids by volume of the material are accurate. However, the percentage will change if any thinner is added to the coating.
- The wet film thickness gage is generally of a standard notch configuration. The notch-type gauge consists of two end points on the same plane, with progressively deeper notched steps in between.
- The dry coating thickness readings on steel substrates are commonly taken using magnetic gauges. Non-magnetically operated equipment is used for nonferrous metallic substrates. Calibration of all coating thickness gages and measurement of coating thickness should be performed in accordance with ASTM D1186 or ASTM D1400.
- Thickness readings are taken to provide reasonable assurance that the specified thickness has been achieved. However, it is not possible to measure every square inch of the surface. Both ASTM D1186 and D1400 state that, when using coating thickness gages, five separate spot measurements should be made over every 100-sq-ft area. Each spot measurement consists of an average of three gage readings taken within a ½” diameter circle.
- QC should document the date and location of the measurements, the type of coat being measured (primer, intermediate, topcoat), and the product and the type of gauge being used, the calibration method, and whether or not the area inspected meets the specification.

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### Pinhole /Holiday Detection

A holiday is a skip or miss on the coating film, while a pinhole is typically a microscopic hole in the coating film. Holiday, pinhole, or spark testing can be used to find the nicks, scrapes, and pinholes in the coating film. Pinholes can be present in any coating layer and should be closed before the next coat is applied. Holiday testing may be required after application of either the next to the last, or last, coat of paint. The test is done when the coating is sufficiently dry but before final cure has occurred so that repair material will successfully bond to the underlying coats.

Pinhole and holiday detectors are of two general types:

- **Low-voltage wet sponge**

Low-voltage wet sponge pinhole detectors are used for finding discontinuities in nonconductive coatings applied to conductive metal surfaces. The low-voltage detector is suitable for use on coatings up to 20 mils in thickness. The basic unit consists of the detector itself, a ground cable, and a sponge electrode. Review the manufacturer's manual in the safe and proper technique on how to use the low-voltage detector.

- **High-voltage holiday detectors**

High-voltage detectors basically function on the same operating principle as the low-voltage units, except a sponge is not used. The instrument consists of a testing unit capable of producing various voltage outputs, a ground cable, and an electrode made of neoprene, rubber, brass, or steel. High-voltage units are available up to 20,000 V and more. High-voltage holiday inspection frequently is required on pipelines and other critical applications. The rule of thumb for high-voltage testing is 100 to 125 V per mil. Too high a test voltage may damage the coating film. Review the manufacturer's manual in safe and proper technique on how to use the high-voltage detector.

### Adhesion Testing

Is commonly conducted using either of two field methods:



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- Tensile adhesion is performed in accordance with ASTM D4541-89. Tensile adhesion requires that a pull stub be adhered to the coating surface using an epoxy adhesive. The pulling force (measured in pounds per square inch) required to pull the stub is a measure of the coating system's tensile adhesion.
- Knife (tape) adhesion requires making and X-cut or a series of parallel and perpendicular knife cuts through the coating (cross-hatch grid), pulling tape from the X or grid, and evaluating the percentage of disbanded coating. The grid or cross-hatch method is used for coatings 5 mils or less. The X-cut is used for coating systems in excess of 5 mils.

**Evaluating Cure**

When a coating is designed for immersion service, the applied coating film must be allowed to cure prior to being placed into service. This curing time is shown on the manufacturer's product information. When the company approves, forced curing may be used to reduce the time between curing and service.

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Approved By: Joe Berry & Safety Committee

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