Common Covered Task 202
Monitoring of Welding Process

Directions

This training guide is to be used by a Veriforce Authorized Evaluator/Trainer and Trainee during on-the-job training (OJT) or prior to an evaluation as a resource. (S) Indicates a demonstration or skill task; (K) indicates a knowledge task.

OJT Reminder

OJT is an active hands-on process. Practice should be as similar to the actual job task as possible. However, if the training is being provided on an actual job site while a covered task is actually being performed, the Evaluator either needs to be qualified on that covered task or be assisted by someone who is qualified on the covered task. The Evaluator should closely monitor the Trainee's practices to ensure safe and correct task performance. At no time should a non-qualified individual perform, or train for, a covered task unless directed and observed by a qualified individual. However, if the *"span of control"* for that particular covered task is "1:0" (requiring only qualified individuals to perform the covered task), the training must be simulated. Training is simulated by "walking through" the task and simulating all actual manipulations (valves, switches, tools, etc.) an individual would use during the performance of a covered task. Simulating includes the use of safety and administrative requirements as if the task were being performed live. Refer to the Veriforce Evaluator Training Program for more on how to conduct formal OJT.

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Recommended Student Training or Resources:

- DOT 49 CFR 192.231
- DOT 49 CFR 192.235
- DOT 49 CFR 192.241(a)
- DOT 49 CFR 192.241(c)
- DOT 49 CFR 192.245
- DOT 49 CFR 192.328(a)(1)
- DOT 49 CFR 195.204
- DOT 49 CFR 195.224
- DOT 49 CFR 195.228
- DOT 49 CFR 195.234

Knowledge: Describe the critical attributes of a welding procedure.

Welding Procedure Specification (WPS) is a formal document describing welding procedures. The purpose of the document is to guide welders to the accepted procedures so that repeatable and trusted welding techniques are used. Specific codes and/or engineering societies are often the driving force behind the development of a company's WPS.

The pipeline operator will outline the specific methods, plans, and overall process in the welding procedure. Some of the critical processes that are defined in the welding procedure are:

- Clamp use requirements
- Base metal (SMYS and group)
- Rod selection (filler material)
- Travel direction and speed
- Polarity
- Alignment
- Gap
- Cleanliness of the surface
- Bevel angle
- Amperage/voltage ranges of the welding machine
- Preheat and post-heat
- Control of the welding environment

Prior to beginning the welding procedure, you should verify that hot work permits have been approved and obtained as required by the pipeline operator.

Check around your work area and clear any combustible materials, such as dry or dead vegetation.

Make sure a fire watch is in place and that you have all required PPE.

Clamp Use Requirements

You should be aware of the clamp use requirements of the welding procedure. The pipe should be properly aligned by the pipe clamp(s) before welding. The clamp(s) will ensure the correct gap between the two pipes being joined by the welding process.

Base Metal (SMYS and Group)

Make sure you are following the correct procedure for the base metal/SMYS (specified minimum yield strength) of the pipe. Specifications could include welding machine settings and/or appropriate rod selection.

Rod Selection/Filler Material

Electrodes, or rods, have a core wire/filler and a coating. Each rod is identified by the number stamped on the coating.

The size of the rod correlates to the size of the bead. The larger the diameter, the larger the bead, and vice versa. Different rod types have different heat ranges and tensile strengths. The rod size and type and base metal type and thickness play a role in selecting the proper rod.

The welding procedure will identify which types of rod sizes are to be used. Some typical rod sizes used in a welding procedure could be 1/8", 5/32", and 3/16", depending on the type of weld, metal type, and thickness of the metal.

Travel Direction

The majority of welds on a pipeline are performed vertically, in either an uphill or downhill motion.

An uphill weld is performed from the bottom-center of the pipe, ending at the top-center.

A downhill weld is done by starting the welding process at the top-center of the pipe, ending at the bottom-center.

There are several considerations that are factored in when determining the direction of travel. Possibly the main consideration is the type of rod used.

For example, a 6010 stick electrode can weld uphill or downhill, but a 7018 electrode in a downhill motion will result in the majority of the weld ending up on the floor.

Always follow the direction and rod selection outlined by the pipeline operator in the welding procedure.

Travel Speed

Travel speed is controlled by the welder and is essential for proper welding fusion.

When the travel speed is correct, the bead is oval-shaped and has uniform ripples in the bead.

If the travel speed is too fast, it can trap slag and gas in the bead, which produces narrow ripples, irregular penetration, and undercut.

If the travel speed is too slow, metal will pile up, producing overlap and deep penetration.

Polarity

Polarity affects the amount of heat that is applied to the base metal. By changing polarity, you can direct the amount of heat to where it is needed.

In ***straight polarity***, the majority of the heat is directed towards the base metal. This is good when more heat is needed to melt the base metal.

In ***reverse polarity***, the heat is concentrated on the electrode. Typically, this is preferred when welding thin pipe.

Alignment

Alignment of the pipe to be welded together is important in achieving a proper weld.

A line-up clamp is often used to ensure the pipe segments to be welded are aligned properly and that there is no ***high-low*** in the alignment.

The welding procedure will outline if a line-up clamp must be used and the minimum percentage of the root bead that must be completed before the clamp is removed.

Gap and Bevel Angle

The gap, commonly known as the root opening, and bevel angle parameters will be defined and illustrated in the welding procedure.

As an example, the welding procedure may state:

Bevel the welding ends to an angle of 30°, +5°, -0°, with a root face of 1/16", +/- 1/32". The bevel shall form a V groove with an included angle of 60°+10/-0. The root opening shall be 1/16", +/- 1/32".

Cleanliness of Surface

To ensure the weld is free of imperfections, the surface of the substrate to be welded needs to be cleaned properly.

Cleaning requirements will be outlined in the welding procedure. As an example, the welding procedure may state:

Clean all rust, dirt, and foreign matter from the bevel surface before welding.

Slag shall be removed from the weld bead surface before the next bead is applied. ***Stringer beads*** shall be ground and cleaned with power tools. The finished weld and adjacent outside surface of the pipe shall be cleaned of all flux, smoke, and weld ***spatter***.

Amperage/Voltage Ranges

An electrode must be operated within a specified amperage range that is compatible with the selected electrode.

If the amperage and voltage ranges are set too high for the electrode, it will melt too fast. The result will be over penetration, spatter, and wide, flat beads.

Having a low amperage and voltage range produces insufficient heat and will not melt the base metal. The result will be a bead with poor fusion that is irregular and piled up.

Preheat and Post-heat

Preheating is accomplished on the base metal or substrate prior to welding.

The preheat temperature is the temperature of the base metal surrounding the point of welding immediately before welding is started. Welding codes generally specify minimums for the preheat temperature, which may or may not keep cracking from happening in every application.

Preheating is typically performed to:

- Drive away moisture from the weld area. This dries the surface and removes contaminants that may cause ***porosity***, ***hydrogen embrittlement***, or cracking through the introduction of hydrogen during the welding process.
- Lower the thermal gradient. Reducing the temperature differential by preheating the substrate will minimize problems associated with distortion and excessive residual stress. If preheating is not carried out, a large temperature differential can occur between the weld area and the parent material. This can cause rapid cooling, leading to the formation of ***martensite*** and/or cracking.

Post-heating is performed after the weld is completed. This aids in slowing down the cooling process, minimizing cracking caused by rapid cooling of the substrate.

The welding procedure will outline the length of time and the method used to post-heat during prescribed ambient temperature ranges.

Control of the Welding Environment

Control of the welding environment is important to help alleviate effects from weather.

This can be in the form of tarps, tents, or umbrellas to protect from the sun, wind, rain, or snow.

The welding procedure will indicate environmental conditions that welding cannot be performed under unless the welder and the work area are properly protected.

The skill of the welder and their ability to follow the requirements set forth in the welding procedure are key in ensuring a proper weld.

The overall safety and integrity of the pipeline can be compromised if any unapproved deviations are performed from the welding plan. Always follow the instructions set forth in the plan before, during, and after any welding procedure.

Knowledge: Describe other procedures/requirements typically required by welding inspection.

Pipeline operators are required to develop welding procedures. The welding procedure is a document that outlines the requirements and specifics of the welding work to be performed.

The procedure is usually written in accordance with the American Petroleum Institute (API) Std1104 or the American Society of Mechanical Engineers (ASME).

The operator may also include additional requirements that are specific to their company policies and procedures.

A technician that is Level II NDT certified should be able to set up and calibrate equipment; conduct the inspection according to procedures; and interpret, evaluate, and document the results of the inspection. They must be familiar with all applicable codes, standards, and other documents that control the NDT method being utilized.

Technicians that perform Level II or III NDT will have a certification that lists their qualification method and expiration date. Prior to starting work, all qualifications must be verified.

Certifications issued from the American Society for Nondestructive Testing (ASNT) through their ASNT Central Certification Program (ACCP) can be verified by phone or online.

DOT 49 CFR § 192.241(c) states: “The acceptability of a weld that is nondestructively tested or visually inspected is determined according to the standards in Section 9 of API Standard 1104”

API-1104, Section 9 covers acceptance criteria for welds on pipelines and related facilities for both new construction and in-service welding.

The standard also covers procedures and acceptance for NDT and inspection of welds by radiographic, magnetic particle, liquid penetrant, ultrasonic, and visual testing methods.

The American Society of Mechanical Engineers (***ASME***) maintains and distributes 600 codes and standards used around the world for the design, manufacture, and installation of mechanical devices.

ASME Section IX contains rules relating to the qualification of welding and brazing procedures as required by code for component manufacture.

Additionally, it establishes the basic criteria for welding and brazing which are observed in the preparation of welding and brazing requirements that affect procedure and performance.

The construction and maintenance of the pipeline infrastructure is an ongoing project. Pipelines need to be built, improved, or repaired. The overall safety and functionality of the pipeline infrastructure is dependent upon the welder’s and inspector’s abilities to follow and adhere to all guidance, policies, and procedures set forth.

Skill: Demonstrate how to take voltage and amperage measurements.

It is important to know how to take voltage and amperage measurements on a generic source as part of this task. Although welding machines will usually display some voltage/amperage information, sometimes the machine may not be calibrated or the output being applied at the welding area may be different due to factors such as voltage drop. Therefore, this objective will describe how to take a basic voltage and amperage reading.

Note that for the performance of this task, neither a welder nor a welding machine is required. You should, however, be able to describe how these readings would be taken during the welding process.

- Taking voltage measurements
- Taking amperage measurements

Taking Voltage Measurements

Direct Current (DC) voltage is the type of voltage produced by batteries and special equipment designed to convert AC to DC and special equipment designed to operate in low voltage applications.

To measure DC voltage, the meter should be set up correctly. First, set the dial to DC and at a range that is above what you are planning to measure. So if you are going to read a device that is connected to 12 volts, you would set the meter to the 20V setting. Next, connect the leads to the appropriate ports, red lead to red or V port, black lead to black or “COM” port.

If you are measuring the DC voltage in a circuit, the leads should be connected in parallel. At this point, the multimeter will display a voltage reading.

Taking Amperage Measurements

Measuring current, or getting an amp draw as it is commonly called, is performed differently than measuring voltage. The method for measuring current that we will review in this training is the clamp method.

The clamp method can only be performed with meters equipped with a current, or amp, clamp. One benefit of using a clamp meter is that it does not require disconnecting any wires.

When using the clamp method, it is important to set up the meter correctly. Remember, current is measured in amps (A). To begin, set the dial to the correct position. Some meters will have two positions represented by mA and A, milliamps and amps. Select the appropriate setting based on the range of amps to be measured.

To take a reading with a clamp meter, follow all safety precautions and clamp your meter around the wire; the meter interprets the magnetic field created by the current flow and displays the amps on the display screen.

Taking Voltage/Amperage Measurements During a Weld

Now that you know how to take voltage and amperage readings, let’s apply this knowledge to describe how to take voltage and amperage measurements during the actual welding process. Although taking a voltage/amperage measurement during a weld is not required for qualification on this task, it is important that you have a good understanding of its application in the field.

Let’s take the voltage reading first. Using a meter, connect the positive/negative meter leads to the corresponding positive and negative welding leads. Follow your pipeline operator’s procedures on where this connection should be made. Typically, it will be at the point of the weld, to reduce the potential for voltage drop.

After the arc is struck, allow a short amount of time for the voltage measurement to level out – the number shown on the meter can be considered your voltage reading.

Next let’s describe an amperage reading. When taking this reading, and depending on your company procedures and the metal you are welding, the machine will be set to DC output. Ensure your meter is set to measure the appropriate amperage. This amperage reading is typically done using a clamp attachment/meter designed for reading amps.

Clamp the meter around the appropriate lead. Follow your pipeline operator’s procedures on where this connection should be made. Typically, it will be close to the point of the weld in order to determine what amperage is being applied at the weld location. When you start the weld arc, the meter will read the actual amperage.

This reading can be used to verify the machine is properly calibrated and is useful to ensure you are following the proper welding procedures.

Knowledge: Describe monitoring of the welding process.

So far we've covered some of the critical attributes and procedures involved in the welding process.

In this objective, we're going to bring these all together and walk through actually monitoring the welding process.

You should first check the welding machine to ensure it is in proper working condition and at the proper settings.

Now that we've checked the welding machine's settings, we can move onto the pipe. You should:

- Check for proper use of the clamp and pipe alignment - verify high/low
- Measure the gap and bevel to the procedure sketch
- Verify pre-heat and post-heat temperatures

As the actual welding begins, you will need to:

- Verify the direction of the weld
- Verify the proper amount of root bead prior to the removal of the clamps
- Time the weld travel speed of all passes

Finally, you should verify the proper methods for cleaning the beads that are being used between passes.

Abnormal Operating Conditions (AOCs)

Candidates are required to possess the ability to **RECOGNIZE** and **REACT** to the listed AOCs for each task. Be prepared to answer questions concerning additional AOCs that may be relevant. Evaluators may ask questions about AOCs throughout the evaluation.

An AOC is defined in **49 CFR §§ 192.803** and **195.503** as:

A condition identified by the pipeline operator that may indicate a malfunction of a component or deviation from normal operations that may:

- Indicate a condition exceeding design limits; or
- Result in a hazard(s) to persons, property, or the environment.

Recognize: Unintentional releases, vapors, or hazardous atmosphere could be signs that an abnormal operating condition has occurred. Examples could include, but are not limited to:

- Blowing gas
- Puddles
- Dead vegetation
- Vapors from casing vents

React/Respond: Proper reactions and/or responses to take in the event of an unintentional release, vapors, or hazardous atmosphere include the following:

- Eliminate potential ignition sources.
- Move to a safe location.
- Notify emergency response personnel, as appropriate.
- Notify the designated pipeline operator representative.

Recognize: Material defects, anomalies, or physical damage of pipe or a component that have impaired or are likely to impair the serviceability of the pipeline are abnormal operating conditions. Examples include, but are not limited to:

- Damaged risers
- Cracks
- Dents
- Gouges

React/Respond: Proper reactions/responses to take in the event of material defects, anomalies, or physical damage of pipe or a component that have impaired or are likely to impair the serviceability of the pipeline include the following:

- Stop the activity and notify the designated pipeline operator representative.
- Mark the location so it may be easily located.

Recognize: An unintended fire and/or explosion on or near the pipeline is an abnormal operating condition.

React/Respond: Proper reactions/responses to take in the event of an unintended fire and/or explosion on or near the pipeline include the following:

- Move to a safe location.
- Notify emergency response personnel, as appropriate.
- Notify the designated pipeline operator representative.

Recognize: A failure or malfunction of pipeline components is an abnormal operating condition. Examples could include, but are not limited to:

- Valve leaking
- Pipe support failure

React/Respond: Proper reactions/responses to take in the event of a failure or malfunction of pipeline component(s) include the following:

- Stop the activity.
- Notify the designated operator representative.

Recognize: An examination that reveals that a pipe or component is of a different material composition than expected is an abnormal operating condition. Examples could include, but are not limited to:

- Different wall thickness, grade (SMYS), or weld process

React/Respond: Proper reactions and/or responses to take in the event of an examination that reveals that a pipe or component is of a different material composition than expected include the following:

- Stop the activity.
- Notify the designated pipeline operator representative.

Glossary

AOC
abnormal operating condition

ASME

American Society of Mechanical Engineers helps the global engineering community develop solutions to real world challenges.

CCT
common covered task

CFR
Code of Federal Regulations

High-low
misalignment of the two parts of the pipeline.

Hydrogen embrittlement
the process by which various metals, most importantly high-strength steel, become brittle and fracture following exposure to hydrogen.

Martensite
most commonly refers to a very hard steel crystalline structure.

Porosity
the ratio of the volume of all the pores in a material to the volume of the whole.

Reverse polarity
an arc-welding circuit in which the electrode is connected to the positive terminal.

Slag
non-metallic, solid material entrapped in weld metal or between the weld metal and base metal.

Spatter
metal particles expelled during welding that do not form a part of the weld.

Straight polarity
the arrangement of an arc welding circuit in which the electrode is connected to the negative terminal.

Stringer bead
the initial bead, also known as the root pass.