1.0. ACTIVITY DESCRIPTION

1.1. The purpose of this document is to describe guidelines for establishing and using quality metrics during or in support of natural gas pipeline and facility construction activities.

1.2. The guidelines in this document are not meant to supersede or replace regulatory requirements, nor are they intended to be all-inclusive of the applicable contractor/owner company quality-related protocols or regulatory requirements. Instead, these guidelines are intended to be supportive and complementary to the aforementioned sources.

1.3. The guideline is to provide common attributes that should be measured in our industry to ensure a consistent approach to industry-wide quality metrics.

2.0. PURPOSE AND APPLICABILITY

2.1. Just as safety is a culture, there is a quality culture of a company or industry. Quality metrics contribute to and assist in improving the quality culture.

2.2. Quality metrics can be:

- **Product Indicators** – reporting the accuracy and completeness of the work product as measured by conformance to established requirements.
- **Process Indicators** – reporting the efficiency and consistency of the work being performed.
- **Perception Indicators** – reporting the level of meeting expectations and/or client or end-user satisfaction.
- **Performance Indicators** – leading and lagging metrics allow client(s) to evaluate contractors in real-time and to guide the development and improvement of quality programs and culture.
- **S.M.A.R. T-** quality metrics should be specific, measurable, achievable, realistic, and time-based
- Quality metrics are most effective when they provide relevant and practical information regarding the work activity without requiring excessive resources or causing schedule delays.

2.3. Traditionally, Industry consensus highlights quality metrics related to welding, coating, hydrostatic testing, and maintaining pipe shape and integrity as baseline indicators for construction projects or activities.

2.4. The Scope of Work for each project should communicate quality expectations, applicable quality metrics, and how performance quality will be measured and evaluated throughout the project.

3.0. ROLES AND RESPONSIBILITIES

3.1. **Management Responsibilities** *(includes all personnel with a supervisory role)*

3.1.1. Confirm that appropriate quality metrics are designated for the project.

3.1.2. Ensure that personnel receive training regarding the applicability of quality metrics during on the onboarding process.

3.1.3. Verify that applicable employees are trained in:

- the duties that they are to perform,
- accurate data collection,
- reporting of quality metrics,
- associated data evaluation, and
- trend analysis.

3.1.4. Verify that the quality metrics program is implemented as planned.

3.1.5. Management is ultimately responsible for Quality Metrics, the validation of results, and Project management plan and/ or Project document updates if shortcomings are discovered from Quality Metrics validation.

3.1.6. Management is ultimately responsible for the participation of all members of the project team in data collection, data evaluation, recommendations, and action close out.

3.2. **Quality Leader Responsibilities**

3.2.1. Provide technical support for preparation and communication of quality metrics.

3.2.2. Review completed project-specific quality metrics to evaluate relevance to the objectives of the contract and scope of work and confirm that applicable metrics, criteria, response actions, and reporting process are clearly communicated.

3.2.3. Serve as an in-house resource for the quality metrics process.

3.2.4. Assist with non-conformance reports (NCR), preventive action reports (PAR), and root cause analysis (RCA) review and response activities.

3.2.5. Confirm employee qualifications meet requirements of assigned job(s).

3.2.6. Review and validate collected quality metrics data.

3.3. **Employee Responsibilities**

3.3.1. Follow the guidelines described in this document and the applicable Project specifications.

3.3.2. Participate in the collection of quality metrics as applicable to job duties.

3.3.3. Report to the Supervisor any recognized quality metric failures that cannot be immediately corrected as well as any high severity quality metric failure.

4.0. ACRONYMS AND DEFINITIONS

4.1. Anomaly: Something that is different, abnormal, irregular, inconsistent, or non-compliant with specifications.

4.2. Coating Defect / Failure: Coating that was not applied correctly or does not meet the specification therefore reducing the effectiveness of the corrosion protection system. Examples include holidays, gouges, low mils, adhesion failures, non-drying film, runs or sags, cracking, or detachment.

4.3. Defect: A deviation from the original configuration (or requirement) of the pipeline or facility. This could be a change in wall thickness due to metal loss, a deformation of the pipe wall, or a crack.

4.4. Dent: A depression that produces a gross disturbance in the curvature of the pipe wall without reducing the pipe wall thickness. The depth of a dent is measured as the gap between the lowest point of the dent and the prolongation of the original contour of the pipe.

4.5. Hydrostatic Pressure Testing: A component of a pipeline safety program and regulatory requirement used to reconfirm structural integrity. It involves filling a pipeline segment with water until it is at a pressure higher than the pipeline will operate.

4.6. Inspection: Evaluation for conformity by observation and judgment accompanied, as appropriate, by testing and/or measurement.

4.7. Lagging indicator: Observable or measurable metric which reports historical performance, such as percentage of welding defects, coating defects. Lagging indicators look back at whether the intended result was achieved.

4.8. Leading indicator: Shows the trend before the defect occurs. Leading indicators give early indications of performance. For example: Equipment maintenance numbers such as mean time to failure (MTTF) and preventive maintenance compliance are leading indicators of equipment failure rates in operation. Welder qualification failure on welding procedure as indicator of material quality issues or procedure quality issues.

4.9. Non-Conformance Report (NCR): Documents the details of an event not compliant with the project specifications identified in a quality audit or other process review. The objective is to make a clear and concise description of the problem so that corrective action can be initiated by management.

4.10. Ovality: Having a rounded and slightly elongated outline or shape, like that of an egg. Ovality in installed pipe is generally measured by a caliper (geometry) pig and reported as a percentage deviation from a perfect circle, e.g., 2% ovality.

4.11. Rework: Any activities required to alter, correct, or repair equipment and / or materials in order to meet requirements and / or address a defect (identified after inspection by client)

4.12. Root Cause Analysis (RCA): A method of problem solving aimed at identifying the primary causes of problems or events. A deeper look into problems or defects to find out why it is happening.

4.13. Weld: The completed joining two sections of pipe, a section of pipe to a fitting, or two fittings.

4.14. Welding Defect: An imperfection of sufficient magnitude to warrant rejection based on the stipulations in the standard used to evaluate weld.

5.0. APPROACH AND METHODOLOGY

Note: Companies are encouraged to add additional metrics that are beneficial to their operations. All quality metrics should define acceptance criteria and/or minimum thresholds to help identify performance trends.

5.1. Welding Quality Metrics

5.1.1. Fewer weld defects requiring repair is indicative of weld quality, welder performance, and efficient project completion.

5.1.2. A repair of a weld is not complete until the contractors welding crew walks away from the weld and says they are done with the weld. A welding crew should be given the opportunity to rework the weld until they are satisfied with their work and turn the weld over to inspection.

5.1.3. Monitoring weld defect rates and the causes of defect rates can be used to continuously improve welding quality and project efficiency.

5.1.4. Establishing reasonable criteria or threshold limits and the actions to take when the limits are exceeded provides a framework to efficiently make use of quality metrics information.

5.1.5. Threshold limits should align with applicable industry standards or conventions and company specifications.

5.1.6. Welding quality metrics and criteria should be stated in company or project performance specifications, e.g., scope of work, project quality plan.

5.1.7. Typical metrics used to monitor weld quality are summarized in Table 1.

Table 1. Recommended Weld Quality Metrics

Applicable Area	Metric	Calculated	Example
Pipeline & Facility	Overall Weld Repair Rate	(# Welds called by NDE / Total # Welds) * 100	3500 full circumferential welds made on project; 50 repairs called by NDE. Overall Repair Rate = (50 / 3500) * 100 = 1.4%
Pipeline & Facility	Cut Out Rate (as % of overall repair rate)	(# Cut Outs / Total # Rejects) * 100	50 Rejects, 2 Cut Outs: Cut Out Rate = (2 / 50)*100 = 4%

Applicable Area	Metric	Calculated	Example
Pipeline & Facility	Defect Type Repair Rate	(# Repairs by Defect Type / Total # Welds) * 100	3500 welds, 50 total repairs: 25 Porosity, 10 ESI, 5 Low Cap, 10 IPD Porosity Repair Rate = (25 / 3500) * 100 = 0.71% ESI Repair Rate = (10 / 3500) * 100 = 0.29% Low Cap Repair Rate = (5 / 3500) * 100 = 0.14% IPD Repair Rate = (10 / 3500) * 100 = 0.29%

5.2. Coatings Quality Metrics

5.2.1. Company specifications and/or project contracts should state physical properties and test parameters that will be used to confirm coating quality acceptance criteria. The coating manufacturer's specifications for preparation and application should be followed at all times.

5.2.2. A repair of a coating defect is not complete until the contractors coating crew walks away from the area and says they are done. A coating crew should be given the opportunity to rework the coating until they are satisfied with their work and turn over to inspection.

5.2.3. Coating quality metrics are key indicators of workmanship. Substandard application will result in coating breakdown which limits the life cycle of the asset due to increased risk of corrosion.

5.2.4. The following aspects of the coating process effect the ultimate coating quality:

- Making sure surface preparation (cleaning, blasting, anchor profile) is done correctly.
- Correctly mixing the coating material (correct A to B ratio, smooth color).

- Applying the coating evenly, to the correct thickness, and with no holidays (gaps).
- Allowing the coating to cure (harden) properly and completely.

5.2.5. Coating quality metrics and criteria should be stated in company or project performance specifications, e.g., scope of work.

5.2.6. Typical metrics used to monitor quality of field applied coatings are summarized in Table 2.

Table 2. Recommended Coating Quality Metrics

Applicable Area	Metric	Calculated	Example
Pipeline	Overall Coating Repair Rate	(# Coating Repairs / total # Welds Coated) * 100	3500 welds made on project, 25 repairs to weld coatings. Overall Repair Rate = (25 / 3500) * 100 = 0.7%
Pipeline	Holiday Repair Rate *(at the time of lowering in)*	(# Holidays Repaired @ lowering in / Total LF Inspected) * 100	Holiday Repair Rate per Linear Foot = (1000 / [3960 * 40]) * 100 = 0.63%

5.3. Pipe Quality Metrics

5.3.1. Company specifications and/or project contracts should state physical properties and test parameters that will be used to confirm pipe quality acceptance criteria. Standardized inspection and test plans can help ensure inspections of critical control points are consistent across areas.

5.3.2. Establishing reasonable criteria or threshold limits and guidelines on actions to take when the limits are exceeded provides a framework to efficiently make use of quality metrics information. These criteria may vary with the project schedule, e.g., upon receipt of pipe, after installed.

5.3.3. Written pipe handling procedures and supplier qualification programs can be used to prevent pipe quality anomalies such as ovality and dents.

5.3.4. Pipe is checked upon receipt and before stringing for ovality, dents, or other defects that might affect the quality of the installed pipeline assets.

5.3.5. Pipe joints that are outside the tolerances set by pipe specifications such as API Spec 5L and regulatory requirements (49 CFR, Part 192) should be set aside and visually marked as "quarantined."

5.3.6. Hydrostatic Test

- Hydrostatic testing (Hydro-Test) must pass test per Regulatory Requirements (49 CFR 194) and company specifications. Refer to INGAA Foundation guidelines document CS-S-9: Pressure Testing (Hydrostatic / Pneumatic) Safety Guidelines for more information.

5.3.7. Caliper Pig Survey

- Acceptance of dents and ovality observed during caliper (geometry) pig surveys should be consistent with 49 CFR, Part 192, and company specifications.

5.3.8. Typical pipe quality metrics are summarized in Table 3.

Table 3. Recommended Pipe Quality Metrics

Applicable Area	Metric	Calculated	Example
Pipeline	Dents Rejection Rate	(# dig outs or cut outs due to Excessive Dents / total # Miles Inspected) * 100	400 miles inspected, 10 dig outs or cut outs with excessive dents. Dent Rejection Rate = (10 / 400) * 100 = 2.5%
Pipeline	Ovality Rejection Rate	(# Dig Outs or Cut Outs due to Ovality / total Miles Inspected) * 100	400 miles inspected, 22 dig outs or cut outs with excessive ovality. Ovality Rejection Rate = (22 / 400) * 100 = 5.5%
Pipeline	Bends Rejection Rate	(# Rejected Bends / total # Miles inspected) * 100	400 miles inspected, 8 rejected bends Bends Rejection Rate = (8 / 400) * 100 = 2%

Applicable Area	Metric	Calculated	Example
Pipeline	Hydrostatic Test Failure Rate	(# of failures in reason category / # of hydrostatic tests completed) * 100	3 hydrostatic test failures due to test heads deficiency out of 20 completed hydrostatic tests Hydrostatic test failure rate due to test head deficiency = (3 / 20) * 100 = 15%
Pipeline	Caliper Pig Survey Anomaly rate	# of anomalies / mile inspected) * 100	400 miles inspected by caliper pig survey; 10 anomalies detected. Caliper Pig Survey Anomaly rate = (10 / 400) * 100 = 2.5%

5.4. Documenting, Tracking, and Reporting Quality Metrics

5.4.1. It is recommended that companies establish an internal quality metrics collection and tracking process such as a centralized database with defined data entry responsibilities and procedures.

- With a centralized data collection system, trends in quality metrics can be monitored in addition to using the metrics for real-time quality-driven decision making.
- Entering metrics-related data into a centralized system will aide in the ability to efficiently report and evaluate the data.
- Using a compilation of industry-wide quality metrics data, these guidelines can periodically be reviewed and refined to increase the impact the quality metrics process has on natural gas pipeline construction and operations.
- Properly documenting and recording quality metrics provides visibility into quality issues and helps prevent future adverse occurrence. Recording of quality metrics also supports continual improvement of process and systems

5.4.2. Documentation templates and the approach used to collect data will vary from company to company, but at a minimum should capture the following:

- Quality Metric, e.g., weld repair rate, coating crew repair rate, excessive ovality rate.
- Data needed to perform calculations, including measurement units (as applicable).
- Calculated result for the metric.
- Pertinent Contextual Information, e.g., date, pipe outer diameter, new construction or repair/replacement, geographic region.

5.4.3. Each company (or project, as appropriate) should determine appropriate frequencies for reporting, evaluating, and tracking metrics-related data. The frequency should correspond to managing the project-specific risks and routine work procedures.

5.4.4. Aligning quality metrics data with a Non-Conformance Report (NCR) or Discrepancy Reporting systems can increase the benefits achieved from actions taken when actual rates are higher than stated thresholds and by using the NCR process to improve efficiency and increase consistency in how quality issues are addressed.

5.5. Preventive and Corrective Actions

5.5.1. Preventing Quality Metric Non-Conformances

- Encouraging crew members and supervisors to report minor or potential quality problems can be an effective way to prevent serious defects and improve the quality culture.
- Similar to a safety near-miss program, a preventive action report (PAR) can be used as a simple communication tool to highlight something prior to significant non-conformance event.

5.5.2. Root Cause Analysis and Investigating Quality Metric Non-Conformances

- Risk-based decisions, e.g., event probability or frequency, severity, or impact, are a recommended approach to determine when to initiate a root cause analysis (RCA).
- If appropriate, the company can designate initiation of an RCA when quality metric criteria are exceeded and/or exceeded multiple times.

- The purpose of an RCA is to evaluate and mitigate problems that are preventing achievement of a quality metric target.

5.5.3. Because of the wide range and variety of potential contributing factors associated with non-compliance with quality metric criteria, conducting deeper dive investigations or an RCA can delay response actions. However, it is important to understand the difference between when to take actions quickly in response to exceeding a quality metric and when to step back and conduct an RCA.

5.5.4. When performing an RCA, remember that multiple factors may contribute to an excursion from a quality threshold or an increasing trend, and the root cause is rarely the first or second layer of contributing factors.

5.5.5. If appropriate, share RCA results with the INGAA Foundation Lessons Learned repository.

6.0. TRAINING

6.1. As part of the on-boarding process, all employees should receive awareness training on quality metrics.

6.2. Refresher training can be provided in the form of a Quality Moment when personnel are assembled for Job Safety Assessment (JSA) or toolbox meetings prior to crews starting work for the day.

7.0. REFERENCES

Current versions of the references automatically supersede the references listed below.

7.1. **Code of Federal Regulations (CFR)**
49 CFR Part 192: Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards

7.2. **International Organization for Standardization (ISO)**
ISO 9001:2015 Quality Management Systems - Requirements

8.0. HISTORY OF REVISIONS

Revision	Date	Description
0	12/1/17	Initial publication of this INGAA Construction Quality Consensus Guidelines document.
1	8/9/22	Revised and refreshed in accordance with review cycle. Expanded scope to include facilities.