Final Report

Project No. 59083GTH

Optimized Weld Records

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Contents

Abbreviated Terms

API	application program interface
CFR	Conditions Found Report
COTS	commercial off-the-shelf
FMM	Fincantieri Marinette Marine
FPY	first pass yield
IDR	Internal Deficiency Report
KPI	key performance indicators
MT	magnetic particle test
NAVSEA	Naval Sea Systems Command
NDT	nondestructive testing
NMD	Navy Maintenance Database
NNS	Newport News Shipyard
NSRP	National Shipbuilding Research Program
PT	penetrant test
QA	quality assurance
QC	quality control
RAP	Rapid Deployment Project
ROI	return on investment
SAT	satisfied
TIP	test inspection plan
TIR	test inspection report
UNSAT	unsatisfied
UT	ultrasonic test
VT	visual test
WPS	weld procedure specifications

1. Executive Summary

The Optimized Weld Records Project was completed for the National Shipbuilding Research Program (NSRP) Rapid Deployment Project (RAP). The project mapped weld process record requirements and digitalized weld reports. The goal of this effort was to create a digital version of weld reports and test these reporting tools in a shipyard environment for both repair and new build projects, with the goal of driving process improvements to the Navy.

Notably, when meeting with the stakeholders many benefits were discovered by switching to paperless weld records:

- Increased transparency of inspection to the welding process
- Improved efficiency of weld requirement validation and deployment efforts
- Automated weld requirement and record data available to decision makers for assessment in Business Intelligence Tools and to refine process
- Archived weld requirement and record data for future use
- Reduced daily costs and save engineers and inspector time

Prior to this project, a commercially available quality control (QC) reporting system was originally developed for and used successfully by industrial coating contractors. The Optimized Weld Records project was funded by NSRP, and its primary goal was to modify the product's functionality and user interface to better suit the requirements of weld inspectors working on Navy ships in line with Navy Standard Item 009-12 for weld, fabrication, and inspection. The project also created a means to provide data to the US Navy stakeholders in an acceptable manner with a number of system additions.

The project met its objectives by developing paperless, optimized weld records that provided:

- A digital user interface that produces weld reports that adhere to NAVSEA specifications
- Digitalizing weld requirements and records from a specification for a yard specific database
- PDF generation of records
- An iPad application accessible offline, as well as a web application
- Auto-fill fields based on associated field value selections
- Business intelligence data queries

The program is now suited for use in a Navy shipyard. To execute the digitalization of welder and welding operator qualification records and tracking the Navy shipbuilding community will need to support further initiatives.

2. Acknowledgements

This project would not have been successful without the assistance of a number of people. Both Navy and Industry representatives provided critical feedback to the project team and were involved with evolutions of this paperless quality assurance (QA) technology. In particular, representatives from Fincantieri Marinette Marine (FMM), Newport News Shipyard (NNS), Vigor

Shipyard, and Naval Sea Systems Command (NAVSEA) provided time and technical expertise throughout this project.

3. Background

Many processes are performed on marine vessels during their initial construction and repair. NAVSEA welding and nondestructive testing (NDT) practices require the acquisition of requirements or procedures, the recording of data, and the reporting of QA data gathered during construction. This data is compiled following the completion of various critical inspections. NAVSEA welding and NDT operations are classified into four types:

- Welding requirements
- Record of welding
- NDT requirements
- Record of NDT

A qualified welder or welding operator needs requirements before beginning work in order to make a sound weld. Codes, blueprints, engineering notes, and weld procedure specifications (WPS) are a few examples of the areas where this information is found. Records are information gathered regarding the materials, processes, and personnel used after each weld operation is finished. Welder qualification records, filler and base material certificates, supervisor/quality assurance representative sign-offs are among the details that are added to a weld's record. NDT has a similar process for their requirements and records.

Procedures shall adhere to regulatory requirements and proper documentation must be reported to customers to ensure they are followed. Customers could be commercial or the government, and each has different standards for quality control and reporting. Today, each inspection produces multiple paper records, and the amount of data that is gathered is very considerable. A project's set of documents will encompass several hundred pages. Proper evaluation of welding quality requires a trained individual to observe and measure elements of the process at various stages of welding. These quality assurance techniques are costly, inefficient, and difficult to implement.

By taking advantage of currently available technology, the Navy community will be able to improve efficiency of managing and collecting QA/QC data. In addition to the reduction of paperwork, additional advances are shown in Table 1.

Table 1 - Benefits of Paperless QA System

Process Improvement	Cost Reduction
Increase transparency of inspection to the welding process	Minimize or eliminate delays associated with adjudication of unsatisfied items
Improve efficiency of inspection efforts	Reduce inspection cost
Transmit inspection data quickly and easily to decision-makers	Expedite decision making, reducing analysis cost and associated downtime
Archive inspection data for future use	Eliminate costs incurred to re-create history for assessments
	Prevent costly rework
Leverage inspection data to its fullest extent	More accessible information could be used for more efficient planning, facilitating process improvement, troubleshooting, etc.

To fully cover all aspects of welding operations, information from shipyards will be obtained to analyze current regulations and record keeping. To understand the regulatory requirements and processes for welding, TruQC and EWI conducted multiple requirements gathering sessions with organizations that currently conduct these activities. These organizations included Fincantieri Marinette Marine (FMM) for analysis of the new build process and Vigor to understand ship repair. This data will be examined and used for both this project and possibly for a future welding RA project to encompass the full weld process.

The Navy and Commercial Shipbuilding communities can increase the efficiency of managing and collecting weld lifecycle data by leveraging existing technology. The use of a database software application can provide access to all essential documentation for each weld in a single location. The database's cross-referencing functionality will also connect the driving requirements for individual variables identified in specific documents. In a nutshell, all of the requirements and records for a weld, as well as the documentation that drive those welding processes, will be linked and available through a single software program. This project will start to streamline these processes by digitalizing required documentation in TruQC and helping to submit it electronically to required parties.

4. Previous and Related Work

This project leveraged work performed in NSRP SPC Panel Project, entitled “Robust Functional Paperless Paint Phase I, II and III,” (ref. 1, 2, 3) that successfully modified commercial off-the-shelf (COTS) technology to output QA data in accordance with the requirements of NAVSEA Standard Item 009-32. Most weld reports are processed by hand, on paper, and then transferred into an Excel document. TruQC would completely replace those antiquated and costly processes by consolidating all paperwork and workflow processes to an integrated software platform. Key aspects that would benefit this project would include:

- Digital user interface for report generation
- PDF generation for records
- Auto-flag out of spec conditions
- Auto-fill fields based on associated field value selections (Work Item/Location)
- "Add from Device" workflow for Bluetooth import of data from Elcometer material thickness (MTG) and precision thickness gauges (PTG)
- Offline capable app
- Web app accessible
- Data queries for business intelligence

Features, which take advantage of the paperless technology in the QA process, include:

- Electronic event notification
- Automate unsatisfied reporting and resolution
- Quality control reports for contractor process improvement
- Real time review of the 009-12 data and ability to run queries
- Ability to bring the pertinent data in to close the Test and Inspection Plan (TIP) automatically in Navy Maintenance Database (NMD) via an application program interface (API)

Return on investment (ROI) has been discovered in previous and related work that include significant time and cost reductions in the areas of inspection preparation, inspection, report production, defect evaluation, conflict resolution, and inspection strategy update. According to Elzly Technologies' independent ROI analysis (ref. 4), TruQC technology reduced clients reporting time and provided cost savings of up to 390%. Labor hours have been decreased by more than 40% at other companies, resulting in net savings of more than 28% and a 316% ROI in the first year. The minimal savings is one hour per person, each day at the regular $75 per hour rate, for a total savings of $1800 per inspector every month.

Other Navy shipyards found a significant return on investment after deploying TruQC. In one yard, TruQC was utilized for two different, labor-intensive forms. One form took just more than seven hours to complete, while another required 56 hours. When comparing these processes before and after TruQC, the shipyard saved nearly 20% on labor hours. The customer realized a 331% ROI in the first year of using the TruQC app when the net savings were compared to the fixed investment expenses. Another yard that employed TruQC saw a 100% reduction in corrective action requests and saved 480 hours ($36K) on documentation processing.

An internal study also showed that a multinational petrochemical company reduced overall time to plan, execute, prepare, and evaluate needed reports by 33% by using TruQC's visual inspection tool at downstream plants. After payback, this led to annual savings per facility that ranged from $1.5M to $2.3M.

5. Accommodating & Digitalizing Current Workflows

It is important to note that not all shipyards are organized the same way. TruQC may be set up to fit any shipyard's workflow.

New Build Workflow

When a new vessel for the US Navy is completed, it is divided into smaller sections that are integrated to build the ship. Each yard sets their ship hierarchy in a different way and the software can conform to each yard's specific set up. At FMM, each ship or hull may have numerous grand modules, and each grand module may have multiple unit modules. Then, each grand module or module will have a number of compartments and tanks. Panels make up the compartments and tanks, while panels are built up of sub-assemblies. It should be noted that grand modules do not always include modules. Furthermore, not all panels are made up of sub-assemblies.

This breakdown is used to ensure that weld inspections are assigned to the correct ship part. Inspections are performed once welds have been completed and documented in the Visual Inspection Checklist. If any defects are discovered, they are documented and submitted to the Welding Team for resolution. After addressing any defects, the weld is visually evaluated again, and the results are recorded in the Visual Inspection Report. This method is repeated until no issues are identified. The completion of the required inspection is recorded in the Test Inspection Report.

Regulations or the Quality Control Manager may require additional testing for a work item for a welding location, such as nondestructive testing or static load tests. Tests are done in the same manner as visual inspections, and any defects found are submitted to the Weld Team for remediation. Once all defects have been addressed, the welder continues the process and performs a visual inspection before repeating the follow-up tests.

A Module Readiness Review is performed once all testing has been completed and no defects have been discovered in a module. This audit comprises a physical audit of all Test Inspection Reports to ensure that all required inspections were completed by comparing them to the Test Inspection Plan.

Ship Repair Workflow

The ship repair process is performed on existing marine vessels and is typically focused on specific portions of a hull, or ship that require repair. Again, each yard can set it up differently, but in Vigor's case repair projects are arranged by work item, and inspections are grouped by locations within that. The ship repair process shares many characteristics with the new build workflow, but it also supports commercial welding, which has fewer reporting requirements than the US Navy. In both circumstances, the ship repair workflow is divided into the following ship pieces: hull/ship, compartments/damage control, and components.

When a Navy ship has to be repaired, the repair specifications are sent to the contractor along with illustrations indicating where each weld should be performed. Following the completion of the welds, the QA team receives a TIP from a third-party system or working within an Excel

document. The TIP includes details on all of the welds that require inspection as well as the type of inspection required for each.

Each structural weld is initially visually inspected, and the results are recorded in the Joint Tracker form. Defects are submitted to the Welding Team for repair when they are identified. After all repairs have been performed, the welds are visually inspected.

When a weld on high-pressure piping is completed, it is classified as P1 or P2, and inspections and testing are recorded in the Piping Tracker. When defects are found in structural welds, they are reported to the Welding Team for repair. After all repairs have been performed, the welds are visually inspected once again.

FPY and Weld Surveillance Checklists are completed during the visual inspection process. The Weld Surveillance Checklist is used to ensure that all procedures are followed and documented properly. During these inspections, First Pass Yield (FPY) reports are filled out with metrics on welding activities and defects discovered, allowing key performance indicators (KPI) to be recorded. The purpose of these reports is to track performance in order to uncover trends that may be corrected and improved

The TIP also indicates whether more extensive NDT is required. The required NDT test is performed and recorded on the associated form. If any of the tests fail, the results are sent to the Weld Team for repair. When the repair is finished, the inspection process starts over with visual inspections.

During these inspections, FPY reports are filled out with metrics on welding activities and defects discovered, allowing KPI’s to be recorded. The purpose of these reports is to track performance in order to uncover trends that may be corrected and improved.

Once all weld inspections have been completed and no defects have been identified, a final inspection is performed, and the results are manually transferred to the third-party system, which feeds NMD**.**

The workflow diagram for New Build and Ship Repair is shown in Figure 1 and Figure 2.

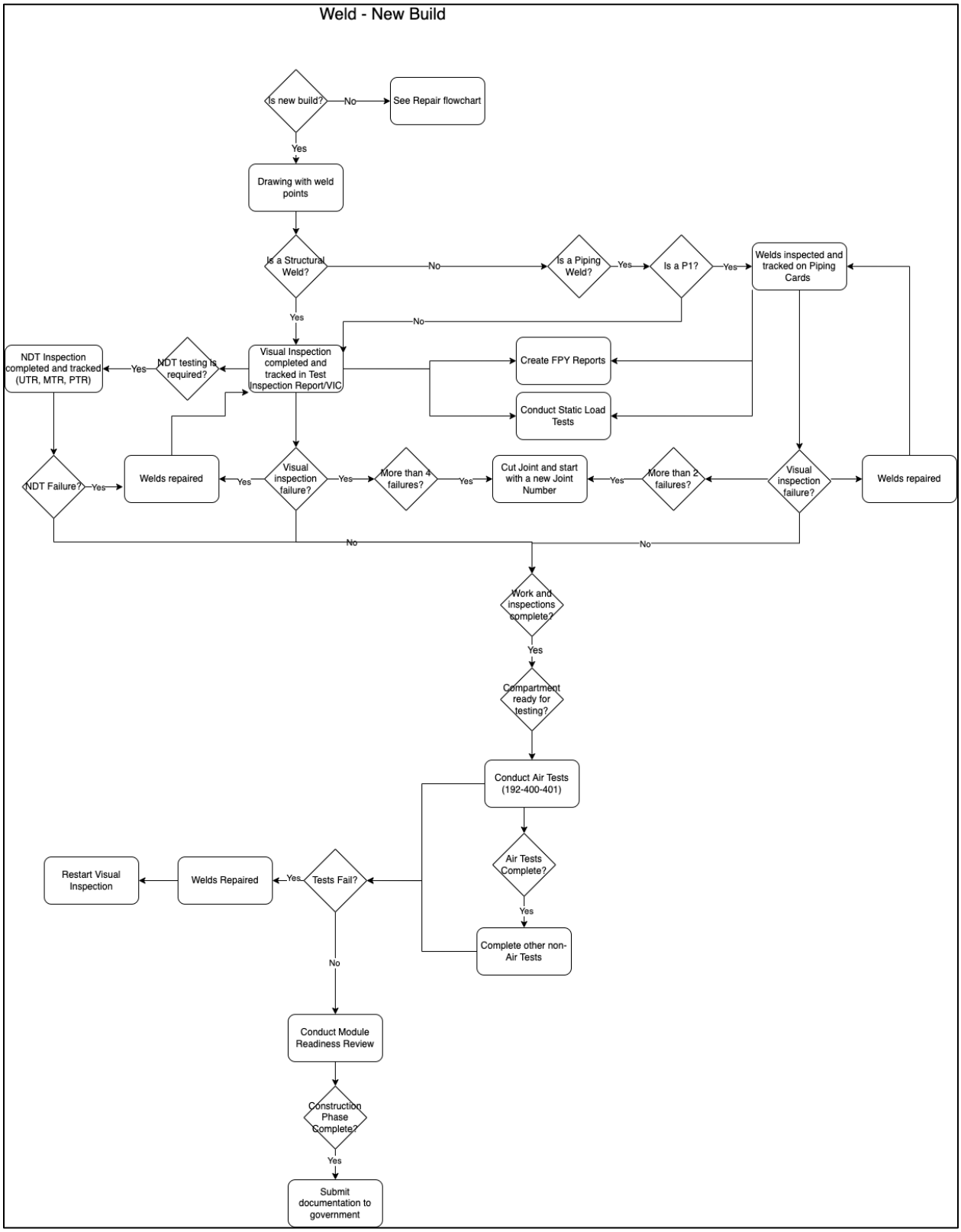

Figure 1. New Build Workflow

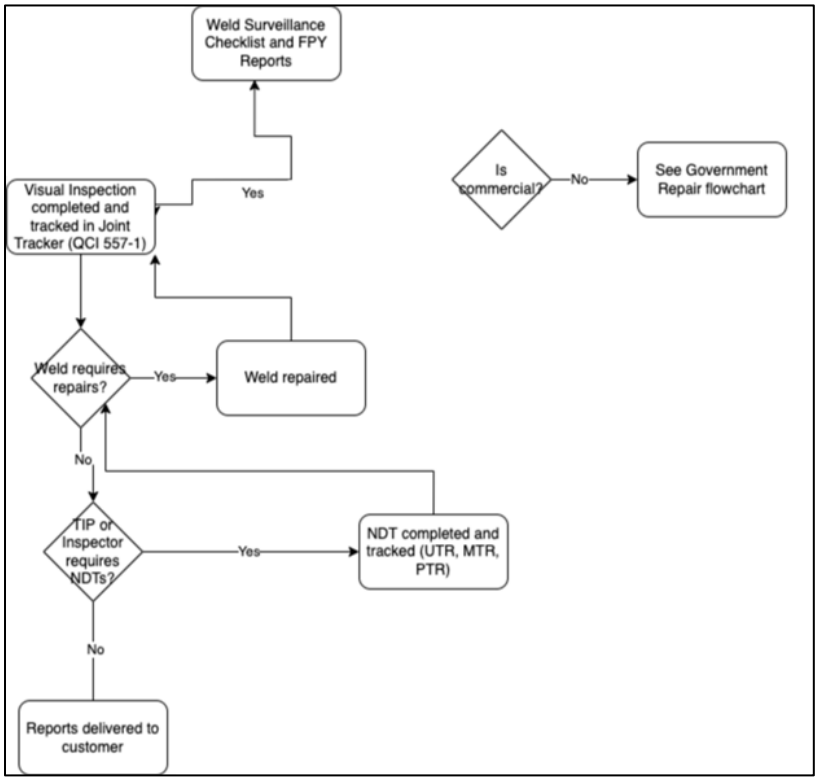

Figure 2. Ship Repair Workflow

6. Approach

To accomplish the items above the following tasks were performed:

6.1 Task 1 – Discovery

- TruQC met with FMM and Vigor to understand the current weld process, workflow, reporting and requirements.

6.2 Task 2 – Discovery Input

- TruQC compiled and organized discovery finding and solicited input from partner yards related to findings.
- Input was organized and included in the development plan.

6.3 Task 3 – Feedback

- Sent wireframes to NSRP yards for feedback and compile results.

6.4 Task 4 – Test Environment

- TruQC developed a test environment for shipyard weld lifecycle reporting.

- FMM and Vigor tested in this environment.

6.5 Task 5 – Implementation Test

- TruQC transitioned the production version of the weld requirement and provided application to a larger group at FMM and Vigor for implementation.
- TruQC provided training and support for the implementation.

6.6 Task 6 – ROI

- During this process, inspections were collected using the traditional paper method, as well as using TruQC for the purpose of comparison and proving commercial ROI in the weld segment.

6.7 Task 7 – Final Report

- Compiled the final paper with results.

7. Results and Discussion

During the combined kickoff meeting the optimized weld records RAP kickoff slides were reviewed. Description of next steps and a schedule of discovery meetings with both FMM and Vigor were proposed. In general, common items occur between both FMM and Vigor. A slew of forms, specifications, procedures, checklists, records, logs, charts, work instructions, reports, and examples were exchanged and reviewed. This drove discussion as to how each was used, populated, and how it would be digitalized. Separate meetings were held with both FMM and Vigor to ensure each shipyard's process and documentation was well understood.

7.1 Task 1 – Discovery; Task 2 – Discovery Input

Discovery is defined as how TruQC and EWI learn about each shipyard’s current process; where it is effective and identifying areas for improvement. TruQC and EWI virtually met with FMM seven times for discovery meetings and Vigor five times for discovery throughout the project. This took place over the length of the project, but for an existing new yard, this process should just take 4 to 6 weeks. Below are examples of information gathered during these meetings.

FMM

During meetings with FMM the following items were discussed:

- Boat structure
- Key terms
- SOC
- Unique identifiers
- Current process
- Structural TIR
- Piping TIR

- QA test procedures
- Module readiness review
- Reports and report workflow

Feedback on the current process was also discussed which included how cumbersome it is to find old records and how difficult it is to validate tests and audits. During these meetings, a demo of the product occurred and revisions of the workflow diagram. Copies of the above forms were provided by FMM to understand what information is collected when these tests are completed and what happens when they fail.

Vigor

During meetings with Vigor the following items were discussed:

- Reports and report workflow
- NAVSEA Standard 009-12
- Weld and Inspection Symbols
    - Penetrant Test (PT) Report, Magnetic Particle Test (MT) Report, Ultrasonic Test (UT) Report and Visual Test (VT) Report Forms
- Feedback on the current process was also discussed which included how documents are currently printed out on carbon copies, signed, and participating parties retain a copy.
- Differences between commercial and Navy work
- Welder and welding operator qualification tracking
- Many forms are living and travel lengths of welds.
- Records are often hard to locate.
- Discussion of typical day of welder and inspectors
- Intranet is currently used for specifications.
- Superintendents are tasked with putting binders together with QA documentation.
- Conditions Found Report (CFR) is created in JIRA and was provided.
- FPY Work Instruction

Copies of their reports were provided by Vigor to understand what information is collected when these tests are completed and what happens when they fail.

After all this data was gathered from both shipyards, workflows were finalized, and wireframes were proposed. Common ground between the Ship Repair process and New Build process were also found. These outputs were then submitted for feedback and results were compiled in Task 3.

7.2 Task 3 – Feedback

During the project the NSRP yards were surveyed for feedback during the over twenty meetings and the results were received. Great feedback was received from FMM, Vigor, and the project team. Each time an item of change was given, a ticket would be issued to update the wireframes or workflows. This was a living list of items for change and or improvement based on the outputs of Tasks 1 and 2. After iterations of this process, the wireframes and reports were approved to develop the test environment in Task 4. These finalized wireframes and reports are described below.

7.3 Task 4 – Test Environment

Based on the input collected in previous tasks, TruQC created a test environment for shipyard weld lifecycle reporting. This allows FMM, Vigor and EWI to use this environment as a sandbox for testing the TruQC software.

The project team was exposed to a new Admin Area called Work Items by TruQC. Users with the appropriate rights can populate all Work Items for either a New Build or a Ship Repair project in this area. In addition, each Work Item allowed users to populate several locations and their associated attributes.

When a Job is created, a user can associate it with a Work Item and a location so that the relevant data can be loaded into the Report. This process eliminates the need for duplicate data entry for each Report and enables the quick generation of data summaries as needed.

It should be noted that the process for creating Work Items and Reports for both New Build and Repair will be the same. Some fields, however, may not be used where they are not required. New build projects, for example, may use module and grand module in their structure whereas Ship Repair may leave those values blank and will not appear on the Report.

Third party software or a spreadsheet provides the data needed to populate Work Items. To help speed up the process of populating Work Items in TruQC, an import can be created to allow all necessary data to be imported.

The Test Inspection Report (TIR) was left out of TruQC because it is currently utilized to ensure that all needed Work Items are performed. The introduction of TruQC Summaries was provided to display the output of all report data in an Excel format.

A collection of reports for both New Build and Ship Repair have been established and can be activated for an account dependent on the type of weld work being conducted. All essential Work Item attributes are imported into the reports so that they can be linked to the inspection and testing data. Furthermore, a collection of reports that apply to both New Build and Ship Repair was generated. Table 2 displays all Navy Standard Item 009-12 specifications and how the information was digitalized.

Table 2 – Navy Standard Item 009-12 Digitalized Items

Standard	Paragraph	Upload/Attach	Form	Database	Library	Location
MIL-STD-1689	5.2.1	x				Employees
MIL-STD-1689	5.2.2	x				Employees
MIL-STD-1689	5.2.3	x				Employees
MIL-STD-1689	5.2.4	x				Employees
MIL-STD-1689	5.2.5	x				Employees
MIL-STD-1689	5.2.6	x	x			In-Process Weld Surveillance Form 71
MIL-STD-1689	5.2.7	x				Filler Metal Identification Log 70
MIL-STD-1689	5.2.8		x			In-Process Weld Surveillance Form 71
MIL-STD-1689	5.2.9		x			Repair 75 & NDE Forms 66-69
MIL-STD-1689	5.2.9.1		x			Visual Inspection Checklist Report 73
MIL-STD-1689	5.2.10	x				In-Process Weld Surveillance Form 71
MIL-STD-1689	5.2.11		x			In-Process Weld Surveillance Form 71
MIL-STD-1689	5.2.12			x		Database
S9074-AQ-GIB-010/248	4-6.2			x		Database
S9074-AQ-GIB-010/248	5-5.1	x				Employees
S9074-AQ-GIB-010/248	6-3.5			x		Database
S9074-AQ-GIB-010/248	6-4.10	x		x		Employees
S9074-AQ-GIB-010/248	6-4.10.1	x				Employees
S9074-AQ-GIB-010/248	6-4.10.2	x				Employees
S9074-AQ-GIB-010/248	6-4.10.3	x				Employees
S9074-AQ-GIB-010/248	A-4.5.1	x				Employees
S9074-AQ-GIB-010/248	A-4.5.2			x		Database
S9074-AQ-GIB-010/248	C-2.2	x				Employees
S9074-AQ-GIB-010/248	C-2.3			x		Database
S9074-AR-GIB-010/278	4.1.3		x			In-Process Weld Surveillance Form 71
S9074-AR-GIB-010/278	4.1.3.2			x		Database
S9074-AR-GIB-010/278	13.2.10		x	x		Visual Inspection and Repair Report 72
S9074-AR-GIB-010/278	13.2.10.1			x		Database
MIL-STD-22	All				x	Library
MIL-STD-2035	All				x	Library
T9074-AS-GIB-010/271	1.6.8	x				Employees
T9074-AS-GIB-010/271	1.8		x	x		Weld Record Card
T9074-AS-GIB-010/271	3.4.9			x		Database
T9074-AS-GIB-010/271	3.4.15	x				Weld Record Card
T9074-AS-GIB-010/271	4.3.1.9		x			Magnetic Particle Inspection Report 69
T9074-AS-GIB-010/271	5.4.1.2		x			Liquid Penetrant Test 66
T9074-AS-GIB-010/271	6.5.4		x			Ultrasonic Test Report 68
T9074-AS-GIB-010/271	6.6.4.5		x			Ultrasonic Test Report 68
T9074-AS-GIB-010/271	7.3.3		x			Eddy Current Test Report
T9074-AS-GIB-010/271	8.5		x			Visual Test Inspection Report 67
T9074-AS-GIB-010/271	A.7	x				Weld Record Card
T9074-AS-GIB-010/271	B.8		x			Ultrasonic Test Report 68
T9074-AS-GIB-010/271	Fig. 6-12		x			Ultrasonic Test Report 68
DOD-STD-2185	4.1	x				In Record
DOD-STD-2185	4.2.3	x				In Record
MIL-STD-2191	6	x				Employees
S9CGO-BP-SRM-010/CG-47C	All				x	Library
S9086-RK-STM-010/CH-505	All				x	Library

The following reports were developed:

<u>New Build Reports</u>

1. Visual Inspection Checklist
2. Weld Record Card
3. Filler Metal Identification Log

4. VT and 5X Inspection Checklist
5. In-Process Weld Surveillance Form

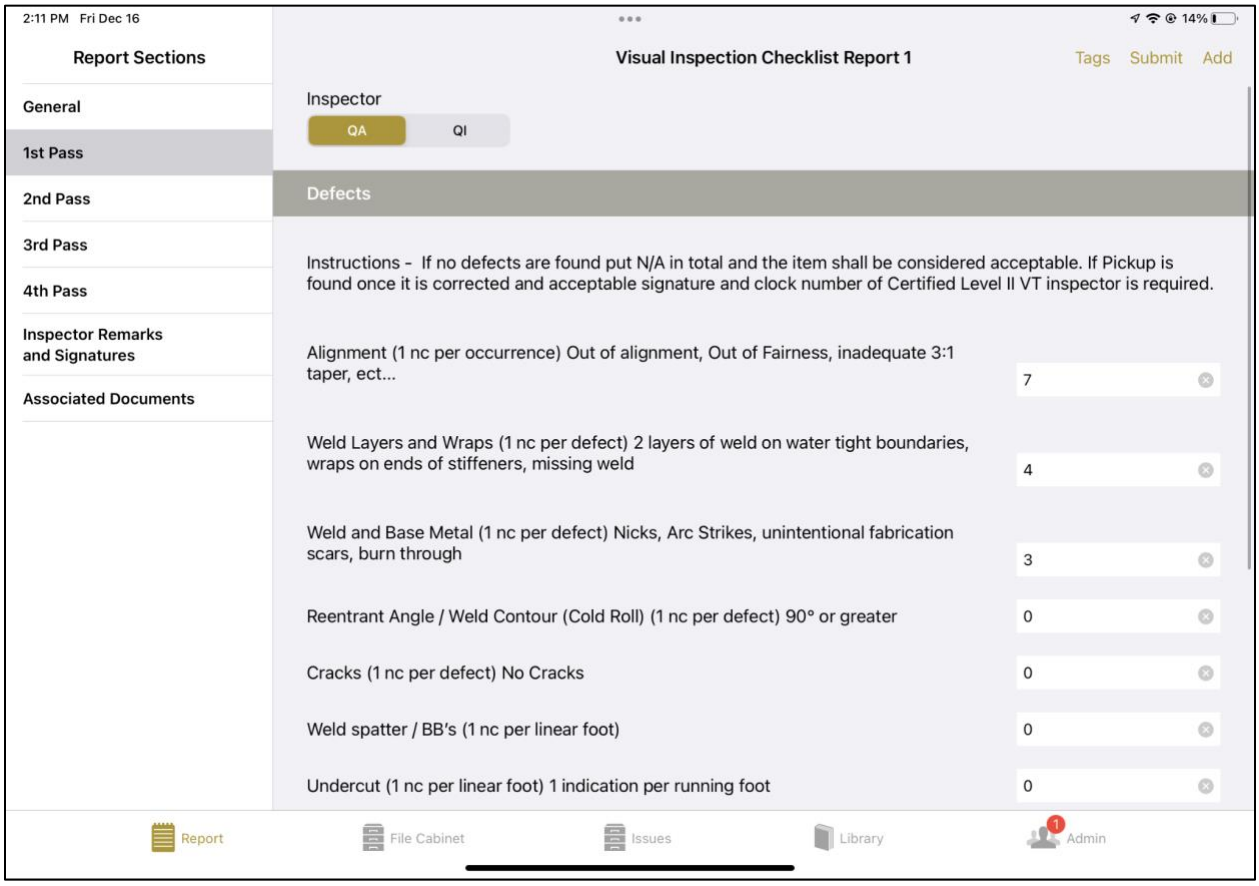

Figure 3. Visual Inspection Checklist in TruQC

Ship Repair Reports

1. QCI-556 Repair Form
2. First Pass Yield Report (FPY)
3. Visual Inspection Report

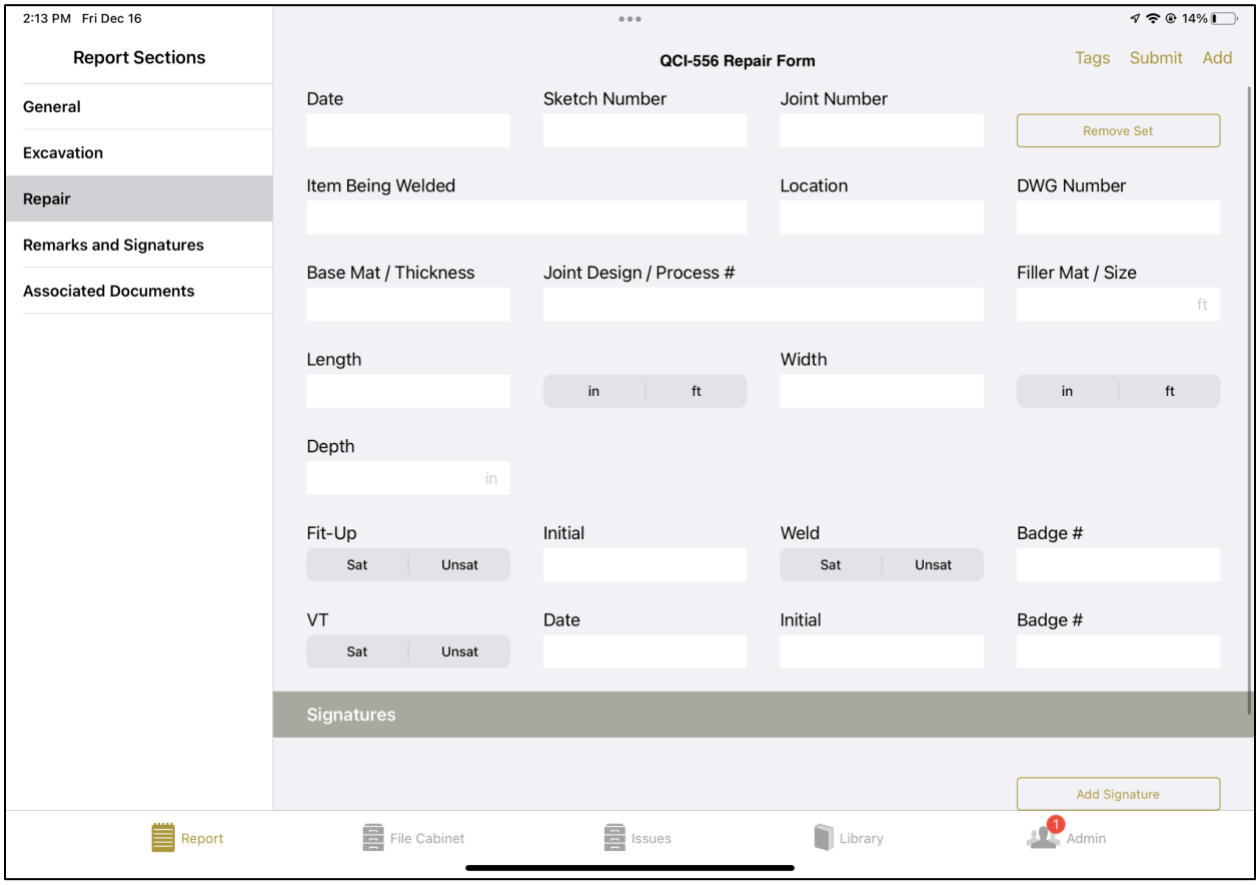

Figure 4. Piping Tracker Report in TruQC

Universal Reports

1. Conditions Found Report (CFR)
2. Weld Surveillance Checklist
3. Ultrasonic Test Report
4. Magnetic Test Report
5. Liquid Penetration Test Report
6. Eddy Current Test Report

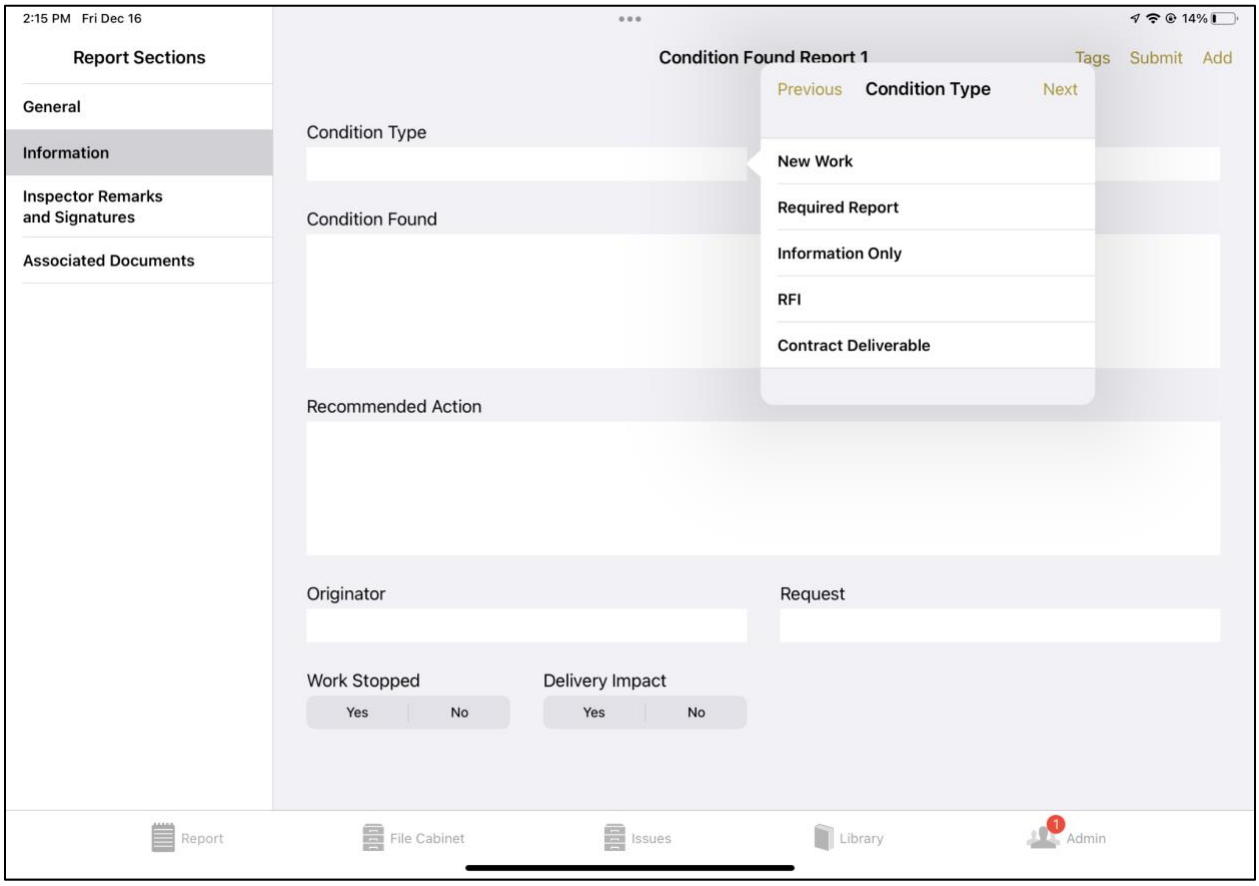

Figure 5. CFR in TruQC (With Drop-Down Selection)

Summaries were also produced to allow TruQC to export all relevant data so that it could be evaluated and loaded into third-party software like ERPs and Business Intelligence Tools. This phase will feature the following summaries:

1. First Pass Yield Summary

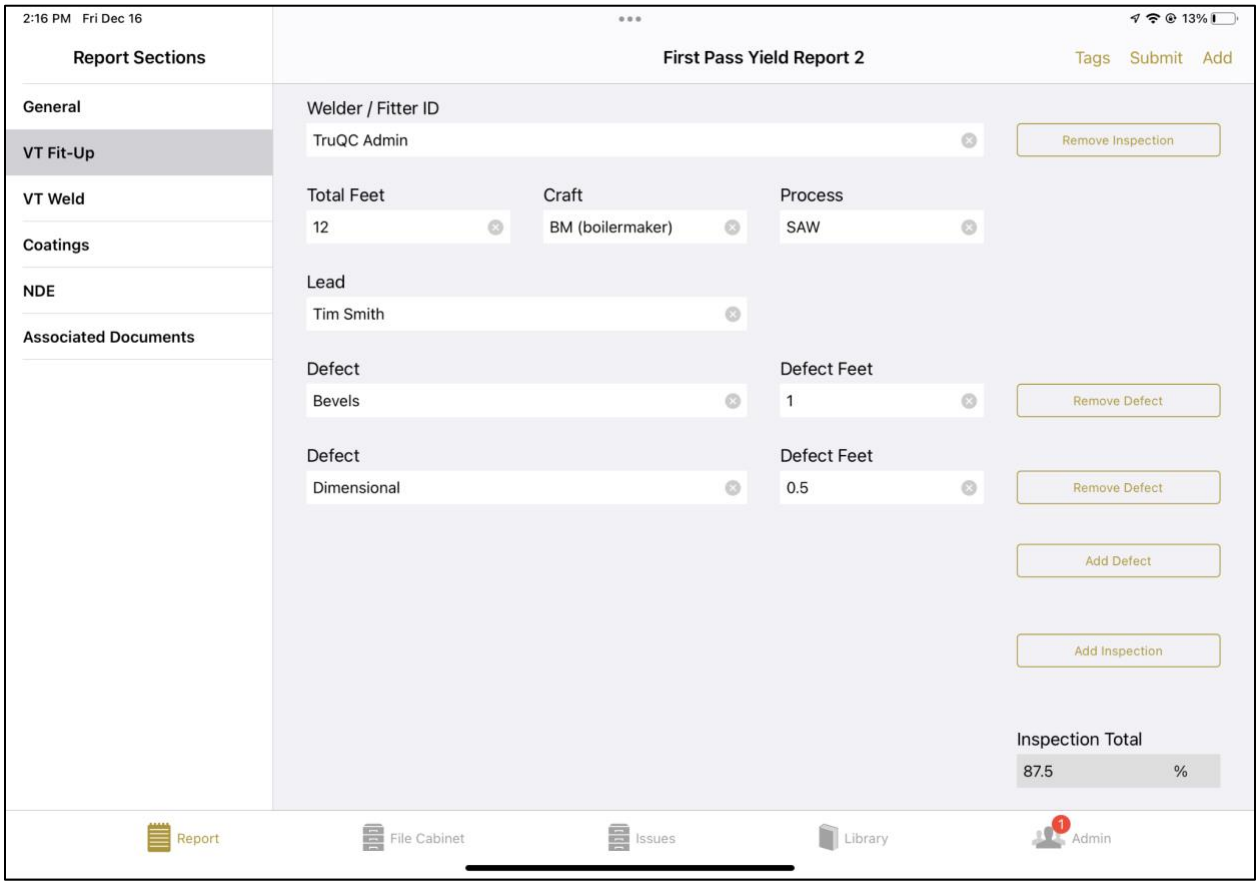

Figure 6. FPY in TruQC

7.4 Task 5 – Implementation Test

TruQC provided the testing version of the weld requirement to a larger group at FMM and Vigor for implementation testing. TruQC also gave training and implementation help as part of this process. A site visit was undertaken following testing at each location. The outcomes are listed below.

Site Visit – Vigor

The site visit to Vigor's Portland, OR shipyard was completed on November 16, 2022, and included representatives from Vigor, TruQC, and EWI. The visit occurred after Vigor's inspection team had the opportunity to use the software and comment on changes that would improve their workflow and ensure that forms in the software aligned with the current inspection forms currently in use. These inputs included how the location of discontinuities were marked, how weld inspection lengths were reported, how penetrant testing variables were reported, and the acronyms used for base material designations.

During the visit, first pass yield reports were targeted as an operation where TruQC could provide time savings to the inspection team. The first pass yield report tracks the welder's percentage of passing welds. The goal for welders at Vigor is to have a first pass yield percentage of 70% or above. If a welder falls below this threshold, a trigger is required to let

management know that a welder is out of compliance. This trigger is referred to as an Internal Deficiency Report (IDR). The process of tracking first pass yield is currently done manually. With the TruQC software, the pass/fail data can be exported to a CSV file where management can then utilize an Excel macro to manipulate the data to observe information like first pass yield.

The best path forward for implementation was also discussed. It was suggested to use TruQC on a specific project or hull for the entirety of the work. It was also discussed that it may be best to test the software with one commercial and one naval hull to understand the impact of different requirements on the software. This will allow for TruQC to get buy-in from supervisors, foremen, and gather important data for a business case.

Site Visit – FMM

On November 2, 2022, the site visit to the FMM shipyard was conducted by personnel from FMM, TruQC, and EWI. The visit occurred following the opportunity for FMM's inspection team to use the software and provide feedback on changes that would improve their workflow and ensure that forms in the software aligned with the current inspection forms in use. These inputs included having TruQC generate NDT procedures, loading all work procedures into a library, defect tracking for weld defects, and additional summary reports such as the number of defects and where they are in the process. Additional future requests were also discussed, including future SAP integration, different permissions for Lockheed Martin (MMC and LCS) and FMM (Frigate), and future Frigate inspection procedures (fields may need updated). Furthermore, FMM provided process examples for both pipe and panels.

Pathways to implementation at FMM were also reviewed during the visit. A statement of work, capital expenses, implementation costs, number of end users (weld, QC/QA), and a request for quote were all included in the formation of a business case for the executive teams. They proposed a 3- to 6-month trial to gain ROI information to support the implementation of weld.

Overall, both shipyards vocalized the improvements TruQC would provide given its implementation into their workflow. These improvements included:

- Increased the effectiveness of inspection activities.
- Reduction of input errors.
- Increased the visibility of the process.
- Instant access to data for executive management and decision makers.
- Searchability of data.
- Data does not physically travel with the process.
- Reduce time associated with out of spec items.
- Reduce time to create repeat reports.
- Information can be used for more efficient planning.
- Reduction of rework

7.5 Task 6 – ROI

Cost Savings Associated with Implementation are listed below:

- The return on investment by switching to TruQC software was analyzed. Inspectors estimated that using the iPad-based system would save them approximately 10 to 15 minutes per inspection report while they were physically at the inspection site. With an average of 30 weld/NDT inspections per ship per day, this adds up to 37.5 hours per week or over a week's worth of total savings per month, greatly improving the overall readiness level of that ship. This time savings was expected to be the result of better contextualized notes, drop-down menus that are pre-filled and use the same language used in the inspection specification.

- When discussing the efficiencies of the TruQC software with the quality team, it was found that more time savings was expected to come from paper inspection records no longer needing to be input to a database after the inspection. Current inspection procedure is to complete the inspection report on paper then input the results of the inspection into a digital form. While transposing the paper report to a digital format does not take long, the ability of the TruQC software to instantly have the report in a digital format will provide efficiency to the process. Instantly uploading the results of an inspection will allow for a more up to date view of welds around the shipyard. This will also allow for corrective action on unacceptable welds to begin as soon as the inspection on the weld is complete.

- Rework is another source of potential cost savings. Several items must be documented during this process. The reporting time would be decreased by 10 to 20 minutes with digitized inputs per inspection. This, combined with the time saved waiting for three QC sign offs, an NDT visual sign off, and final signatures, could save up to an additional 25 minutes per inspection.

- Auditing is the last potential source of cost savings. During an audit, items can be requested for each weld. Within a ship there are thousands of welds, and pages of record for each weld. The time to navigate through these documents can be immense. Within TruQC these items are instantly available by query through the interface. This allows instant access to these records.

7.6 Task 7 – Final Report

This report was compiled by both TruQC and EWI with data gathered throughout the project.

8. Conclusions

Conclusions from this project are listed below:

1. The software developed by TruQC demonstrated the value of digitalization when combined with quality control and quality assurance. Optimized Welding Records were effective for everyday usage by establishing working partnerships with the shipyards.

2. Optimized Welding Records enhanced inspection efficiency and transparency during the welding process. It provides decision-makers with immediate access to data records and archives of weld and inspection data for inquiries, reports, and future usage.
3. Optimized Welding Records save engineering and inspection time with regard to reporting, which lowers daily expenditures.
4. There were opportunities to incorporate extra criteria and documentation for weld and inspection into the software. TruQC system could be used, specifically, to monitor welder and welding operator qualifications and stop welding by unqualified welder or welding operators.
5. The project produced a product that meets the requirements of two shipyards. To gain acceptance of the shipyards and the Navy, the Optimized Welding Records needs to be demonstrated on an active project. A plan should be created to support the adoption of TruQC within the weld record process based on implementation testing results.
6. After this project is finished, more data gathering and in-person demonstrations at NSRP shipyards are anticipated.
7. Feedback and lessons learned from this project will benefit future NSRP and Navy projects that build on digitization efforts, allowing for digitalization of the complete construction process.

9. Recommendations

1. EWI and TruQC recommend the digitalization of welder and welding operator qualification records and tracking.

2. EWI and TruQC recommend integration with additional NDT/NDE gauges.

3. EWI recommends that TruQC work with Regional Maintenance Center QA representatives to identify possible paths to integrate paperless capabilities into the NMD process.

4. EWI should also continue to support TruQC in the development of Optimized Weld Record tools.

10. References

1. Boyd, R., Cogswell, S., “Robust Functional Paperless Paint,” National Shipbuilding Research Program Surface Preparation and Coatings Panel (SPC), (2013).

2. Boyd, R., Cogswell, S., “Robust Functional Paperless Paint, Phase II,” National Shipbuilding Research Program Surface Preparation and Coatings Panel (SPC), (2015).

3. Boyd, R., Cogswell, S., “Robust Functional Paperless Paint, Phase III,” National Shipbuilding Research Program Surface Preparation and Coatings Panel (SPC), (2017).

4. Elzly Technology Corporation. NSRP Surface Preparation and Coatings Panel Project. Future State For Navy Ship Maintenance Painting, (2013).

11. Disclaimer

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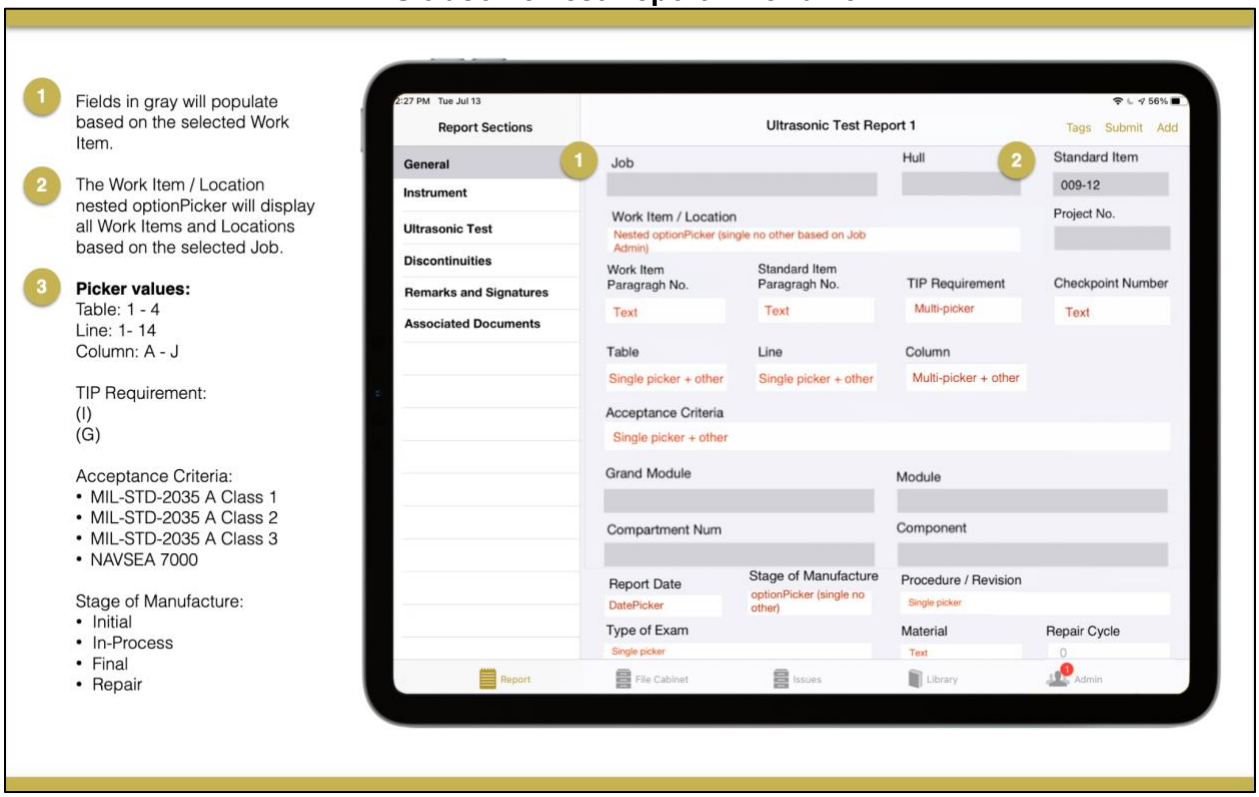
Appendix A: Example of TruQC Wireframes and App

Ultrasonic Test Report Wireframe



1. Each transducer and associated calibration data will be inside a collection.
2. Picker values identified below to associated field:

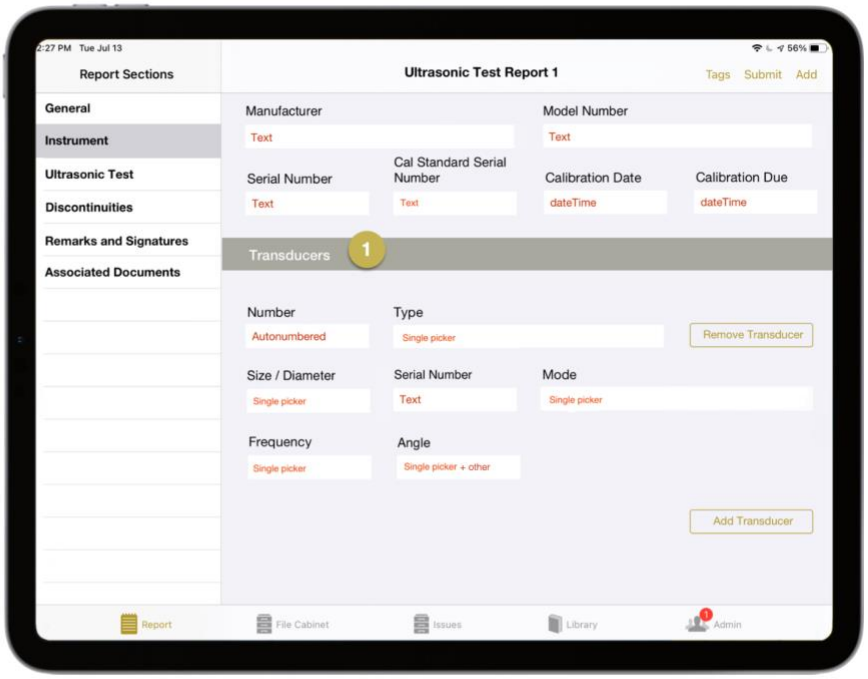
Type:
- Single Element
- Dual Element

Size / Diameter:
- ¼"
- ½"
- 1"

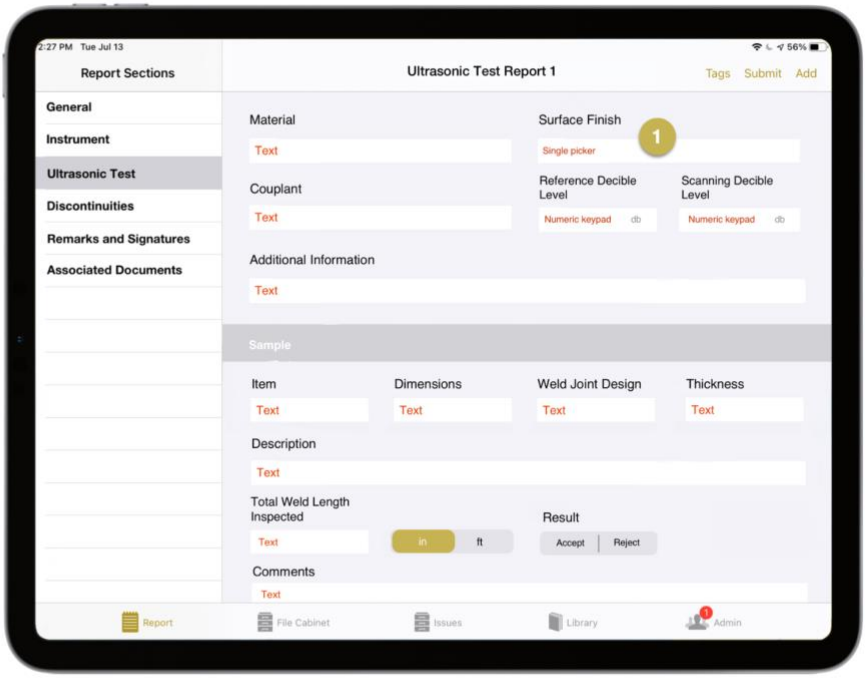
Mode:
- Longitudinal
- Shear Wave

Frequency
- 1 mhz
- 2.25 mhz
- 3.5 mhz
- 5 mhz
- 10 mhz

Angle:
- 0°
- 45°
- 60°
- 70°



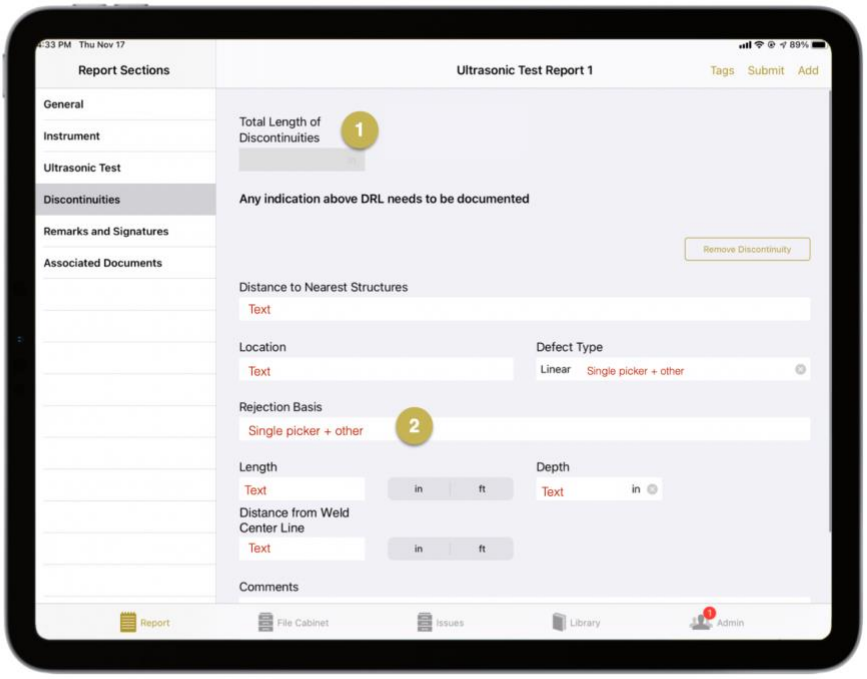
1. Surface Finish picker values:
- As Welded
- Ground Flush
- Rough Ground



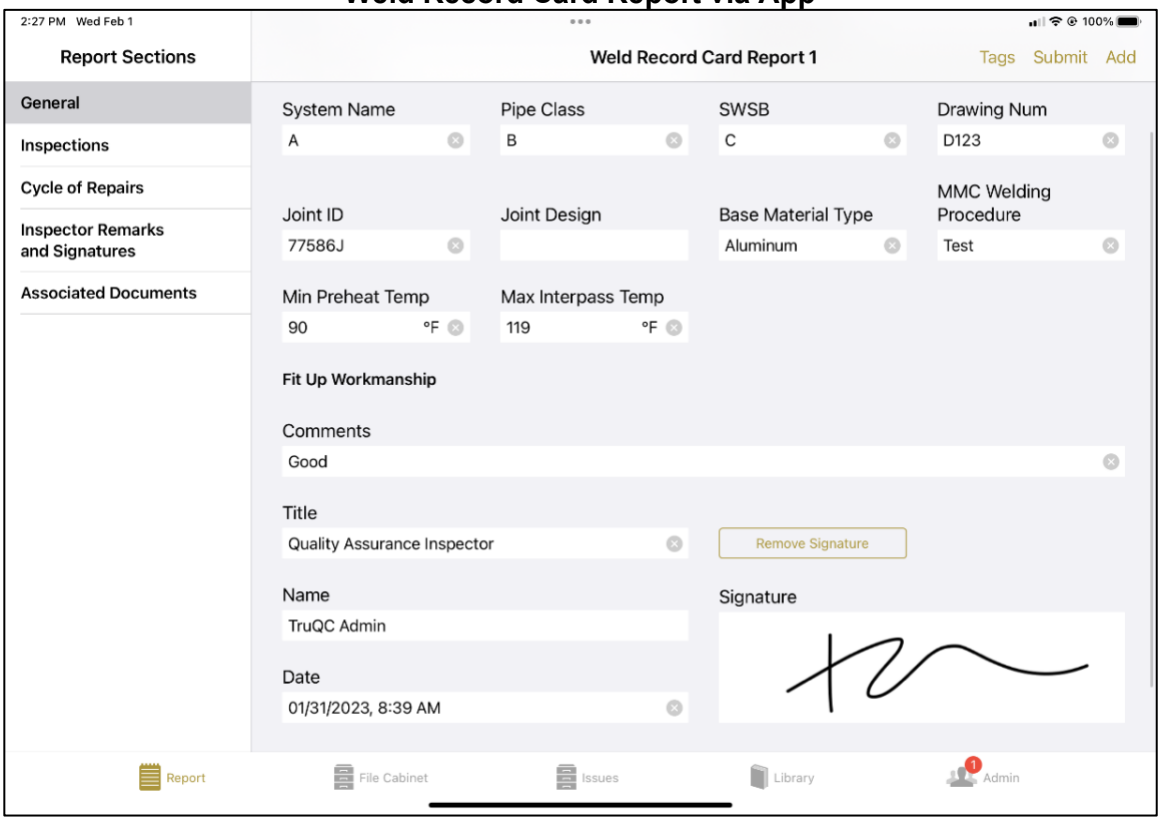
1. Total Length of Discontinuities will display the sum of all Length fields added across collections in a read-only field. Inches will display as the UofM.

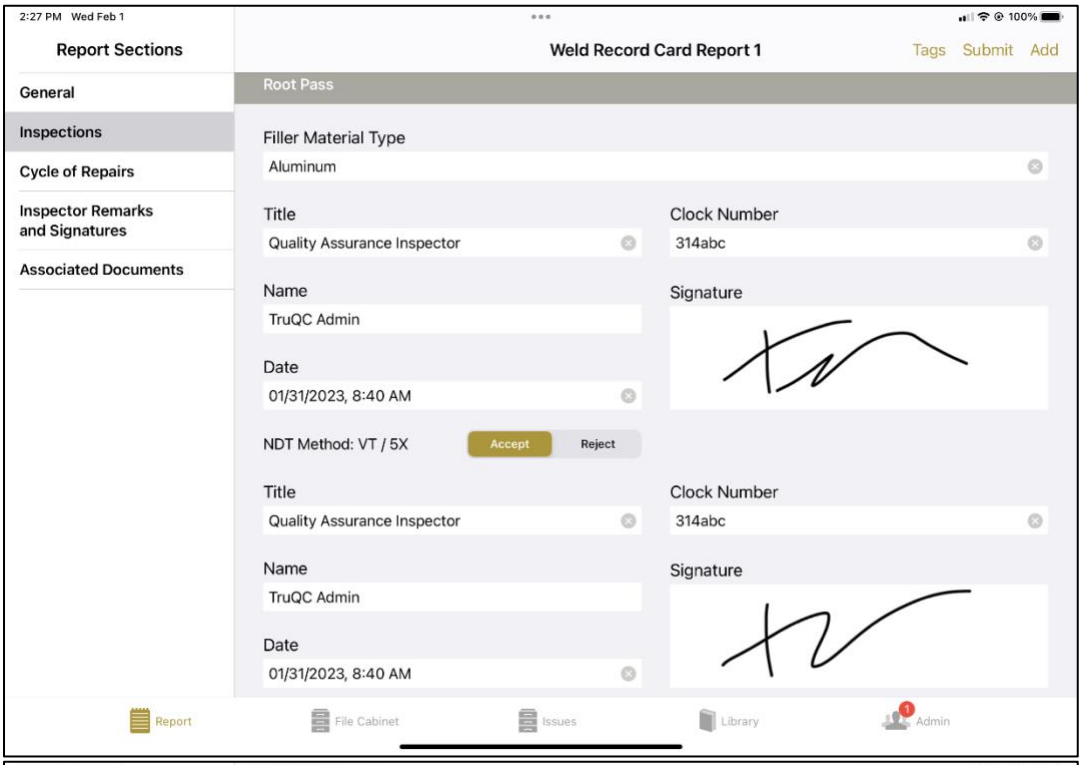
2. Picker values:
Defect Type:
- Linear (this value will display by default)

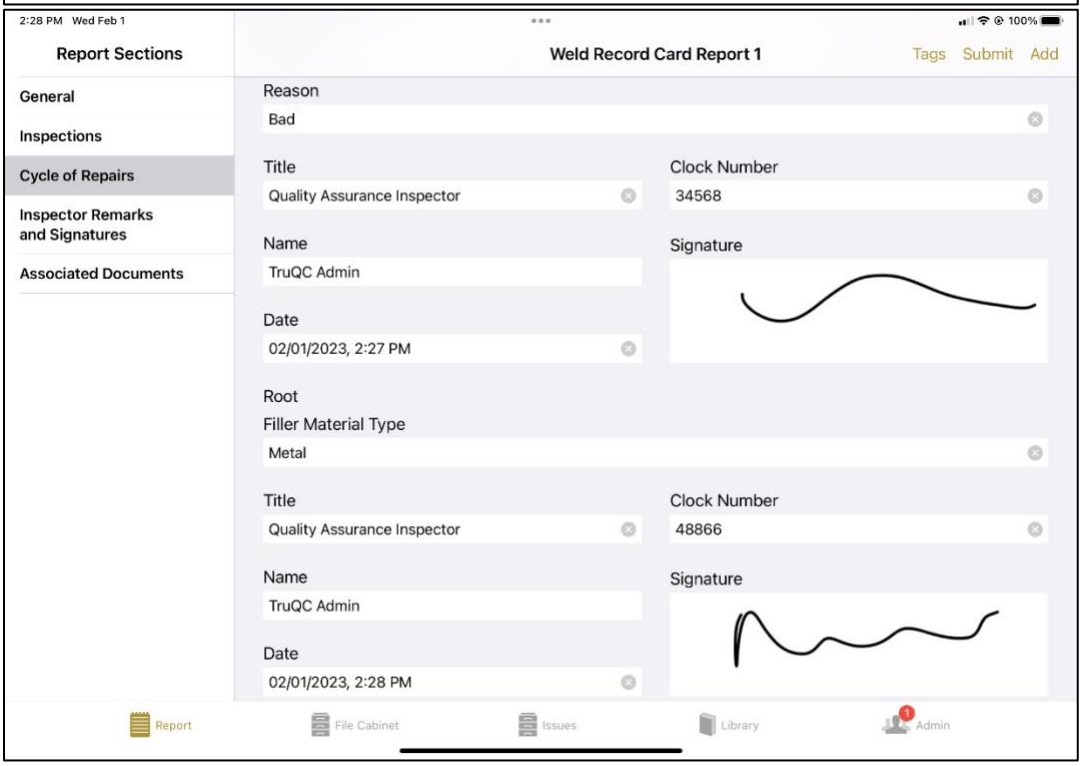
Rejection Basis:
(List provided)



Weld Record Card Report via App




2:27 PM Wed Feb 1
100%
Report Sections
Weld Record Card Report 1
Tags Submit Add
General
Inspections
Cycle of Repairs
Inspector Remarks and Signatures
Associated Documents
Root Pass
Filler Material Type
Aluminum
Title
Quality Assurance Inspector
Clock Number
314abc
Name
TruQC Admin
Signature
Date
01/31/2023, 8:40 AM
NDT Method: VT / 5X
Accept
Reject
Title
Quality Assurance Inspector
Clock Number
314abc
Name
TruQC Admin
Signature
Date
01/31/2023, 8:40 AM
Report
File Cabinet
Issues
Library
Admin


2:28 PM Wed Feb 1
100%
Report Sections
Weld Record Card Report 1
Tags Submit Add
General
Inspections
Cycle of Repairs
Inspector Remarks and Signatures
Associated Documents
Reason
Bad
Title
Quality Assurance Inspector
Clock Number
34568
Name
TruQC Admin
Signature
Date
02/01/2023, 2:27 PM
Root
Filler Material Type
Metal
Title
Quality Assurance Inspector
Clock Number
48866
Name
TruQC Admin
Signature
Date
02/01/2023, 2:28 PM
Report
File Cabinet
Issues
Library
Admin

Appendix B: Examples of TruQC Reports

Final Ultrasonic Test Report

ULTRASONIC TEST REPORT

REPORT #234-345-456 - 20221115-6, SUBMITTED

TruQC

Started: 11/15/2022, 11:08 AM CST - Location: 44.88,-120.19 Submitted: 11/16/2022, 10:49 AM CST - Location: 44.88,-120.19 Approved: N/A

GENERAL

Job Name: 234-345-456
Work Item Paragraph Num: 262-12-001
TIP Requirement: I, G
Table: 3
Column: B
Acceptance Criteria: MIL-STD-2035 A Class 1
Report Date: 11/15/2022, CST
Procedure / Revision: VI-UT-4 Rev 3
Repair Cycle: 2
Description: Final shearwave examination of weld joint 31, repair cycle 2.

Work Item: UWH
Standard Item Paragraph Num: 3.10.3.1
Checkpoint Number: CP-3087
Line: 10
Type of Exam: UT Shearwave

INSTRUMENT

Manufacturer: Olympus
Serial Number: 120266603
Calibration Date: 11/15/2022, CST

Model Number: Epoch 600
Cal Standard Serial Number: 1018
Calibration Due: 02/15/2023, CST

TRANSDUCERS

Number: 1 **Type:** Dual Element **Size:** ⅛" **Serial Number:** 22145587
Mode: Longitudinal **Frequency:** 5 mhz **Angle:** 0°

Number: 2 **Type:** Single Element **Size:** ⅛" **Serial Number:** 1232252
Frequency: 5 mhz **Angle:** 61.5

ULTRASONIC TEST

Material: 5XXX Aluminum
Couplant: Ultragel II

Surface Finish: As Welded
Reference Decibel Level: 56.4 db
Scanning Decibel Level: 56.4 db

SAMPLE

Item: Weld Repair
Weld Joint Design: B1V.1
Description: 100% UT of repair cycle 2 of weld joint 31
Total Weld Length Inspected: 11 in
Comments: No rejectable indications noted at time of examination.

Dimensions: 11"L
Thickness: .75"
Result: Accept

Page 1 of 2

DISCONTINUITIES

Any indication above DRL needs to be documented

Distance to Nearest Structures: 6" INBD of L-6 Longitudinal bulkhead, 42" aft of bulkhead 174
Location: 3-174-0-E
Length: .25 in
Distance from Weld: -.18 in

Defect Type: Linear
Depth: 0.188 in
Orientation: Transverse

REMARKS AND SIGNATURES

REMARKS

If supplemental ultrasonic inspection techniques are used that contribute to the final inspection results, record them here.
If full UT inspection coverage cannot be obtained per the approved procedure, document the location and type of missed coverage, reason and signature to denote case basis approval.

Did you obtain full coverage?: Yes

SIGNATURES

Name: Seth Bishop
Title: Quality Control Manager

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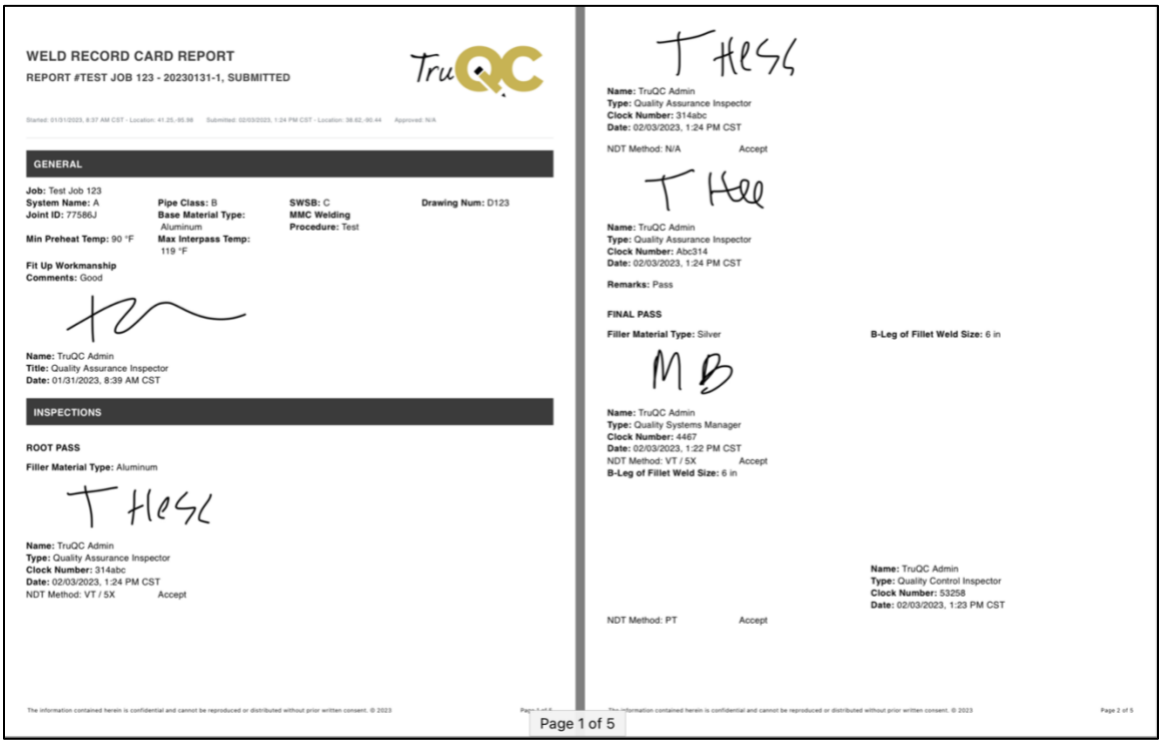
Final Weld Record Card Report



WELD RECORD CARD REPORT

REPORT #TEST JOB 123 - 20230131-1, SUBMITTED

TruQC

Started: 01/31/2023, 8:37 AM CST - Location: 41.25, -95.98 Submitted: 02/03/2023, 1:24 PM CST - Location: 38.62, -90.44 Approved: N/A

GENERAL

Job: Test Job 123
System Name: A
Joint ID: 77586J
Pipe Class: B
Base Material Type: Aluminum
SWSB: C
MMC Welding Procedure: Test
Drawing Num: D123
Min Preheat Temp: 90 °F
Max Interpass Temp: 119 °F
Fit Up Workmanship Comments: Good

Name: TruQC Admin
Title: Quality Assurance Inspector
Date: 01/31/2023, 8:39 AM CST

INSPECTIONS

ROOT PASS

Filler Material Type: Aluminum

Name: TruQC Admin
Type: Quality Assurance Inspector
Clock Number: 314abc
Date: 02/03/2023, 1:24 PM CST
NDT Method: VT / 5X Accept

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Name: TruQC Admin
Type: Quality Assurance Inspector
Clock Number: 314abc
Date: 02/03/2023, 1:24 PM CST
NDT Method: N/A Accept

Name: TruQC Admin
Type: Quality Assurance Inspector
Clock Number: Abc314
Date: 02/03/2023, 1:24 PM CST

Remarks: Pass

FINAL PASS

Filler Material Type: Silver
B-Leg of Fillet Weld Size: 6 in

Name: TruQC Admin
Type: Quality Systems Manager
Clock Number: 4467
Date: 02/03/2023, 1:22 PM CST
NDT Method: VT / 5X Accept
B-Leg of Fillet Weld Size: 6 in

Name: TruQC Admin
Type: Quality Control Inspector
Clock Number: 53258
Date: 02/03/2023, 1:23 PM CST
NDT Method: PT Accept

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