NASA Rocket Stand Piping

36”-112” Cooling System Complex
Pipe Replacement

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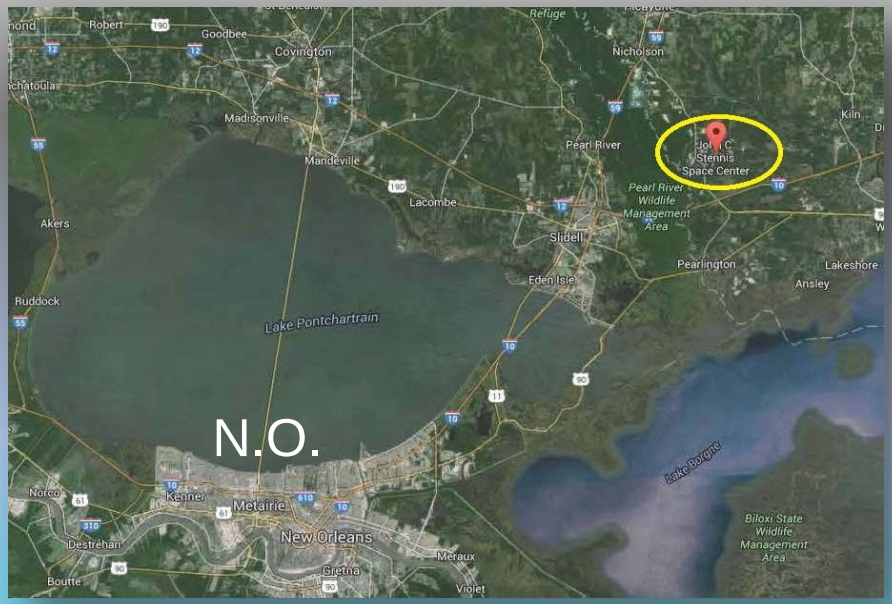
NATIONAL WELDING CORP.

Introduction NASA Stennis



- Strategically located northeast of New Orleans, LA between the rocket manuf. and launch facility at Kennedy Space Center
- NASA's premier rocket engine test center for the USA performed all Apollo Tests plus all space shuttle main engines used on over 130 missions over 34 years.
- All engines have to pass test firings prior to being installed on a launch vehicle.
- Next-generation engines will be tested for cargo flights to the International Space Station and new deep Space Launch System (SLS) to Mars.
- The 13,500 acre site selected in 1961 also includes 125,000 acre acoustical buffer zone plus barge access to deliver large engines.

General Project Overview

Project included replacing a high pressure water cooling system including two complex 102”-112” manifolds connected by a high pressure pipeline.

First manifold located at a pump station feeds water through a 96” x 4000’ pipeline to a second manifold located under the B-Rocket stand.

The rocket stand manifold delivers water several hundred feet up through the structure to spray nozzles that cool the rocket motors.

Over 238 welded pipe connections including over 40 field fabricated compound miters assembled into the existing structure.

All field welding was required to meet 100% RT under ASME including strict assembly tolerances intended for much smaller pipe.

The Construction Team

National Welding Corporation (NWC)	• Responsible to assemble, fit and weld the pipe for Layne Heavy Civil Inc.
Layne Heavy Civil Inc.	• General contractor over NWC and subcontractor to Healtheon Inc.
Healtheon Inc.	• Prime Contractor to NASA
Hanson Pipe (now Forterra Pipe & Precast)	• Fabricated and delivered the pipe
NASA	• Project owner

Key Challenges

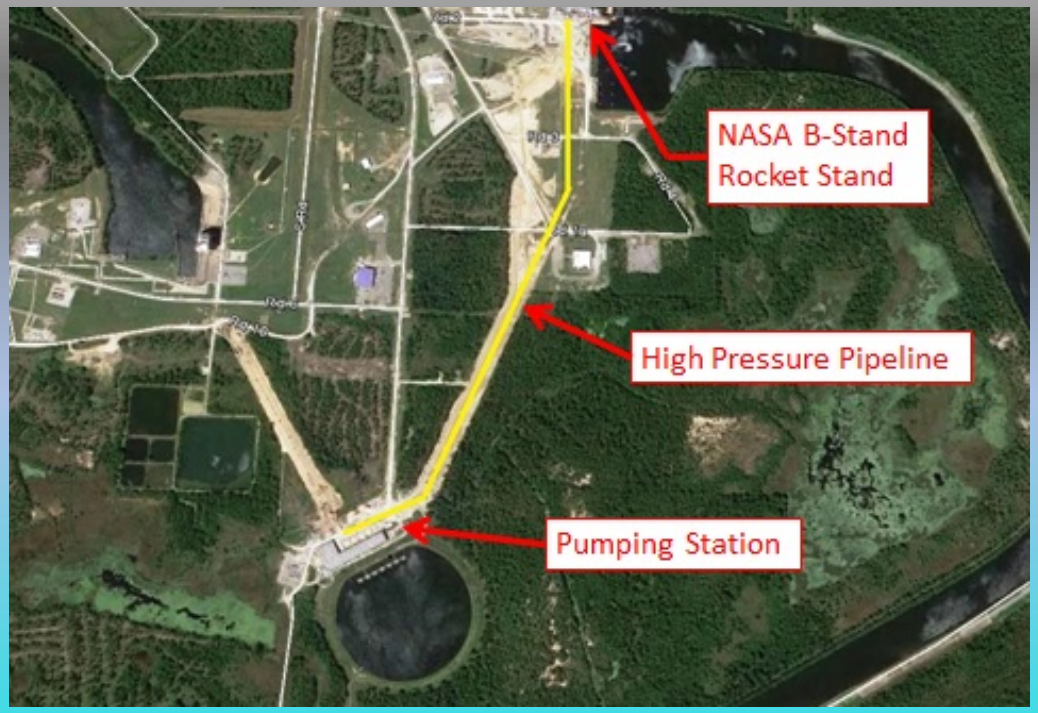
Adapting fabricated fittings to an existing structure and accommodate pipe alignment through existing penetration openings.

Sequencing assembly to minimize re-fabrication of complex fittings.

Material delivery schedule and logistics in a changing work environment.

The combination of these issues were only overcome through daily problem solving and cooperation by all parties.

Construction Sequence

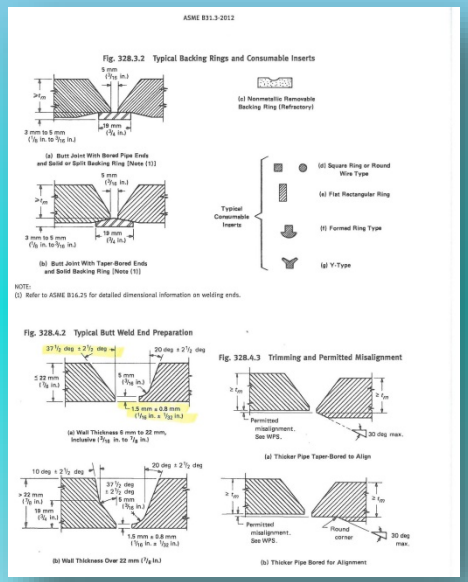


Sequence scheduled to minimize the outage period for the system

- High Pressure Pipeline completed without disabling operations
- High Pressure Pump Station manifold was critical path but allowed a second Rocket Stand to continue operations
- B-Rocket Stand piping/manifold required demolition first but also critical path and was the location of the final tie-in.

Assembly and Welding Requirements

- All field joints were complete joint penetration (CJP) welds , beveled to the inside on pipe diameters over 36” dia. and beveled to the outside 36” and under.
- Bevels, assembly and welding were required to meet the acceptance criteria of American Society of Mechanical Engineers (ASME) B31.3 “Pressure Piping” including 100% Radiographic Inspection.
- Post Weld Heat Treatment (PWHT) was required on many welds within the test stand which exceeded 1” in pipe wall thickness.



Logistics and Documents

- Materials and pipe delivered just before installation.
- Added challenge by sheer number of parts involved.
- Further complicated by constantly changing work obstacles requiring constant changes in the delivery sequence.
- The combination of these issues create a mix of difficult conditions which could only be overcome through daily problem solving by all parties.

High Pressure Pipeline

- High Pressure Pipeline was 96 inches in dia. and approximately 4000 feet long.
- Started near base of the B-Rocket Stand and continued to Pump Station.
- Various trench shoring methods were used.

Pipeline Assembly

Pipe assembly required temporary stabbing guides

Pipe joints were tack welded to secure to the adjoining pipes

Then drifted the loose pipe end to the final line and grade.

Pipe Welding Procedures

96 inch seam x .770” thick = over 44 pounds of weld metal

- This very large weldment justified high production welding methods.
- FCAW-G (Flux Cored Arc Welding with Gas) commonly referred to as semi-automatic welding is much faster, cleaner and has many superior properties.
- SMAW (Shielded Metal Arc Welding) generally referred to as manual stick welding is the more common process.
- Our experience found FCAW was 2.5 to 3 times faster than SMAW.

FCAW-G (Flux Cored Arc Welding)

SMAW (Stick Welding)

Sacrificial Ceramic Backing

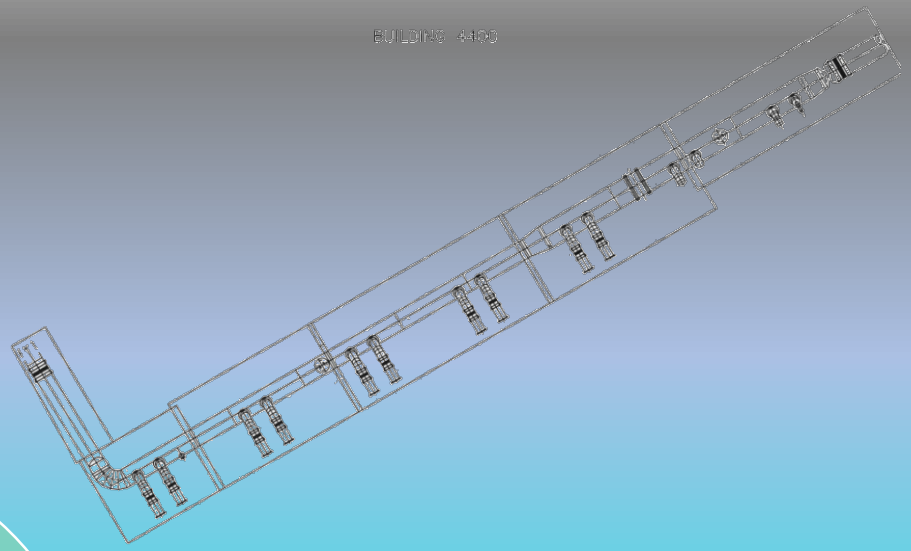
- Ceramic backing rings utilized on the pipe exterior to minimize back gouging and meet ASME B31.3 code.
- Internal welds were completed then ceramic rings are removed .
- Exterior joint is back gouged and ground to remove contaminates .
- Exterior is then back welded.

High Pressure Pump Station

Pump station powered by 10 very large surplus diesel engines pumped water from an adjacent reservoir.

Pump station supplied water for two rocket stands concurrently by isolating valves.

Water was pumped through 10 each 36” dia. plus 2 each 20” dia. laterals into a 112” diameter manifold.

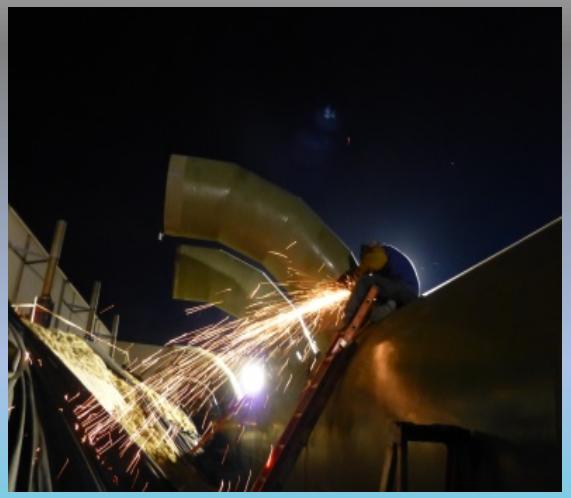


Building 4400 Pump Station plan view

Pump Station Assembly

- Pump Station was built from the larger manifold section then working toward the elbow at the end of the section.
- Considerable caution was needed to install the manifold with 12 each 45 degree laterals connecting to fixed points near the building.
- The tolerances for the pipe joints root gap was .125” which was problematic with the numerous connections and thermal movement issues.
- The sequence and solution for this complex manifold was to install the laterals from the manifold first leaving these sections intentionally long then extend the piping from the building to meet those extensions.

Assembly of Laterals



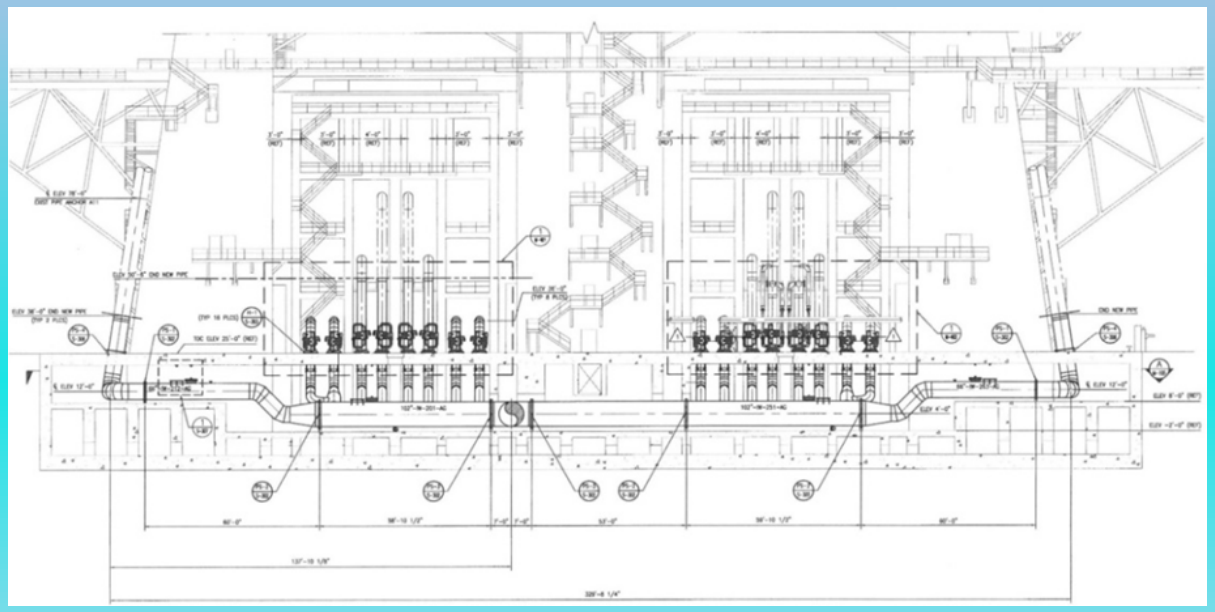
- Leaving the two pipe ends long at the final connections allowed a single compound miter to be cut involving both pipe ends.
- Required over 24 cuts but close proximity of the connecting joints allowed the cuts to be made with high confidence to meet tight tolerances.
- Risk of measurement errors could potentially compound the number of cuts and welds so this method was the least risky.
- During these connections the rocket stands was disabled therefore the work was performed 24 hours per day and 7 days per week until completion.

B-Rocket Stand Manifold

- One rocket stand was now operational. The remaining work involved replacing a complex manifold within the existing vault under the B-Rocket Stand.
- This is a very formidable structure 264 feet tall involving replacement of the main manifold piping located below a 4 feet thick reinforced concrete slab at the base.
- Existing reinforced concrete slab sections were saw cut then removed to provide access to the vault below the stand.

Tough Start

- B-Rocket Stand challenge started with drawings created in 1960's and a manifold was housed within a vault inaccessible prior to construction or pipe fabrication.
- Could not verify accuracy of the drawings or recreate the as-built condition. The original construction allowed pouring the vault ceiling after the pipe assembly.
- Included 16 each 36" dia. 45 degree laterals plus 2 each 66" dia. 8.5 degree laterals which extended up the rocket stand to spray nozzles



B-Rocket Stand profile view

Tight Spaces

- Manifold included 20 openings through a 4’ thick concrete slab just large enough to accommodate the 36” and 66” dia. pipe.
- Butt welded connections, very tight code tolerances and very limited clearance. Only access to remove the original manifold and install the new manifold was a 20’ long by 15’ wide saw cut opening.

Work Underway

- Manifold was disassembled using conventional oxygen acetylene methods and the pieces were extracted through the access opening.
- The installation of the new manifold began at the far ends inside the vault where the 66” pipe exited the vault vertically.
- New manifold progressively blocked clearances as it was installed which dictated the sequence for the installation.
- The means to place the manifold sections utilized pipe carts combine with chain hoists and the sections were lowered by crane from the surface.

Field Fabrication

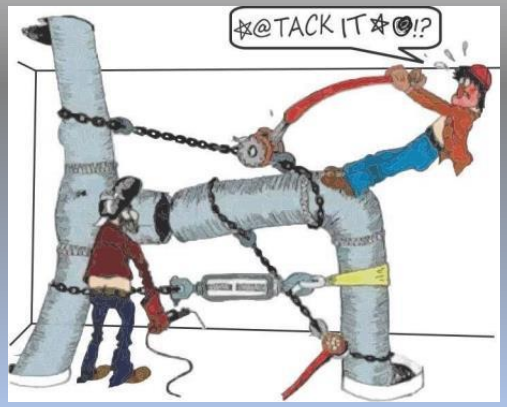
- Crews were required to field fabricate numerous connections to accommodate the complex manifold and meet the fixed openings through the vault.
- Diligent attention was given to measurements before making the cuts as some of the plate in this section involved up to 1.5” thickness pipe weldments which were very time consuming to assemble and weld out.
- Any errors would compound the assembly and welding durations.

Very Tense Moments

- Performed hydro-test after the system was complete except for the final tie-in.
- Final tie-in connections involved 1 each 66” dia. pipe at each end of the stand and required cut off a test head then inserting a short spool section of pipe between the old pipe and the new system.
- The joint tolerance was .125” for this connection and was a formidable challenge given the unusual 8.5 degree angle of the connection .
- Team decided to fill the manifold up to the connection with water to avoid damage to the interior coatings, save time and minimize fill time.
- This connection was made within 2 hours of a mandatory rocket test for a military satellite and generated some very tense moments.

Plan, Plan, Plan

Considerable planning is merited to assemble complex piping



Seasoned team familiar with this type of work is crucial. Interview!

Schedule materials early then verify the parts are correct, complete and staged in the sequence they will be installed.

Redundant equipment and materials should be on site or located within a reasonable distance to assure the work activities are not delayed.

Trial fit and preassemble parts when possible.

Use critical path method (CPM) schedule to break down the major work activities. Updating weekly, daily or even hourly depending on circumstances. All key parties should be involved with scheduling to resolve conflicts.

Conclusion

The logistics involved with expediting materials and coordinating work priorities was of the utmost importance to meet our tight schedule.

The team was required to anticipate problems then adjust the activities to optimize progress on the fly.

Mere hours to spare to meet the scheduled NASA rocket test.

The rewards were dramatic

Questions

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