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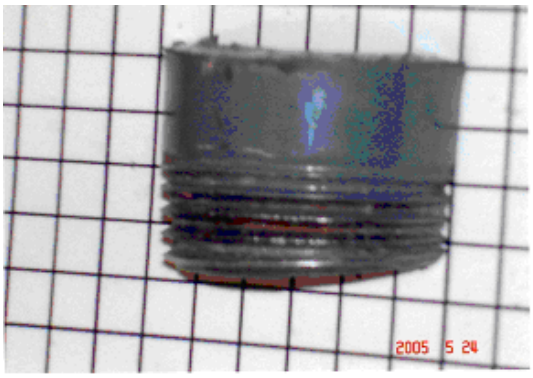
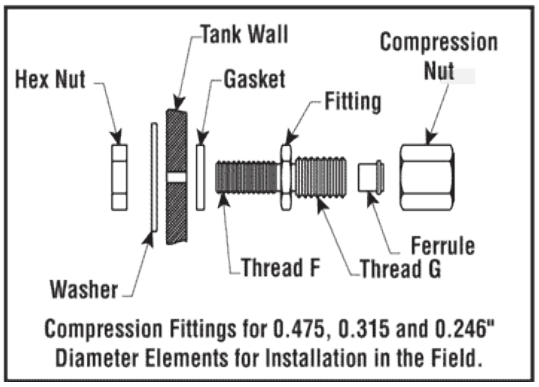
Failure Analysis Case Study

# Failure Analysis of Natural Gas Service Compression Fitting due to Sideway Overload




Key Words: Pipe Fittings, Plumbing, Fracture

Material : Stainless Steel

## Introduction

Two gas "Factory Assembled Transition Fittings" were submitted for determining the cause of failure. The pipe ends were found to be fractured, approximately one week after installation, during final hook up process. Visual examination, mechanical and metallographic analyses was performed on the submitted sections to look for root cause of the failure.

## Visual examination

The assemblies had failed by fracturing of the threads at the end of the ¾ inch NPS coated steel pipe. Deformation of the threads can be seen in figure 1. Examination under a low power stereomicroscope show thinning in the area of the fracture. Stretch marks are visible on the inside diameter surfaces, figure 2.

Figure 1: Metal deformation at the fractured end of the pipe

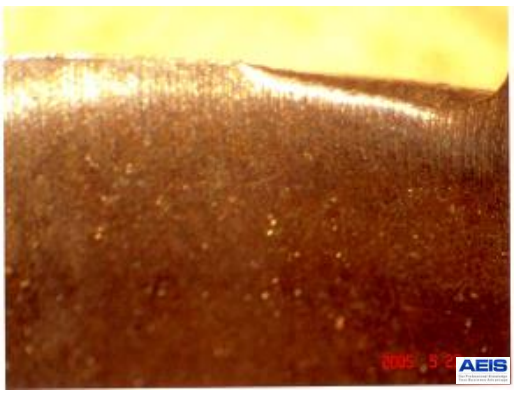


Figure 2: Stretch marks on the inner diameter

Figure 3: Evidence that fracture took place by a side load of the pipe

## Mechanical Test

Tensile test specimens were performed on each of the two ¾ inch pipes with the following results obtained.

| Test Piece | No.1 | No.2 | Required |
|---|---|---|---|
| Yield Strength(lbs.per sq. in.) | 41,100 | 62,800 | 33,500 minimum |
| Tensile Strength(lbs.per sq. in.) | 45,100 | 66,000 | 60,000 minimum |
| Elongation, Percent | 17.5 | 16.5 | 16.0 minimum |

Flattening Test is conducted on threaded section and threaded end

A. Threaded Section

| | No. 1 | No. 2 | |
|---|---|---|---|
| 1st Step | Pass | Pass | No cracks or breaks |
| 2nd Step (flat) | Pass | Pass | No laminated or unsound material |

B. Threaded End

| | No. 1 | No. 2 | |
|---|---|---|---|
| 1st Step | Pass | Pass | No cracks or breaks |
| 2nd Step (flat) | Pass | Pass | No laminated or unsound material |

In addition, longitudinal lengths of the ¾ inch pipes were bent over radius equal to 1.5 times the wall thickness with no evidence of any visible cracks. The mechanical properties conform to the requirements for a Grade B carbon steel pipe for ASTM A 53-01, a standard specification for commercial carbon steel pipe as shown above.

## Microscopic Examination

The failed piece was sectioned through the fracture in the deformed region and the cross section was examined under a low power optical stereomicroscope. The cross-sections showed that fracture had taken place through the root of a thread via a sideways bending load.


Figure 4: Side bending plastic flow, Concave Slide 200x Magnification

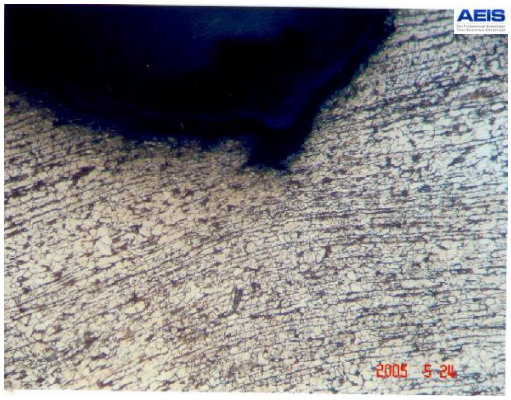



Figure 5: Slide Bending Plastic Flow, Convex Side 202x Magnification

The cross sections were then metallographically prepared and the examined under a metallographic microscope at magnifications up to 800x. Flow lines indicating plastic flow of metal due to side ways loading were observed on opposite wall locations in the fracture zone, figures 4 and 5. The threads have been machine cut but as opposed to being roll formed.

## Discussion

It is evident from the observations noted herein that failure had occurred in a ductile manner. A force was apparently applied at an angle to the pipe axis. The mechanical test results show that the pipes conform to the requirements of a Grade B carbon steel pipe per ASTM A 53-01, a standard specification for commercial carbon steel pipe.

It should be noted that an appreciable wall thickness is lost when threads are cut into pipe. The remaining wall thickness of ¾ inch schedule 40 pipe is close to one third of the nominal pipe wall thickness. The actual wall thickness at the fracture areas could not be determined due to the plastic deformation that occurred when the pipes failed.

## Conclusion

Based on the metallurgical evaluation and the foregoing, it is concluded that the factory assembled transition fittings failed at the ¾ inch threaded pipe and due to excessive applied side ways forces.