

Gas Distribution Pipe Explosion

An unprotected schedule 40 carbon steel pipe ruptured beneath the surface of an essential roadway. The pipe was visibly corroded on its exterior surface. When cut open, black colored deposits but no underlying corrosion was observed on the inside diameter surface of the pipe. Further mechanical damage and abrasion were exhibited on the pipe exterior, especially at a hole several feet away from the fracture. Noncompliance was suspected and an immediate failure investigation was deemed necessary to assign financial responsibility.

The pipe was observed to have failed in its thread roots immediately adjacent to a pipe coupling. To examine the fracture area in greater detail, a sample was prepared for metallurgical examination. The non-corroded areas of the fracture surface were found to exhibit a brittle cleavage mode of failure when subjected to SEM analysis. In brittle failures, small cavities and cracks are initially formed by slip; then, as loading continues, the cracks initiate new cracks in adjacent grains along the cleavage plain similar to the branching of a leaf. In this case, the fracture began at the thread roots spreading towards the center of the pipe in a chevron shaped pattern.

Further metallurgical examination detected several internal and external inclusions with respect to the failed pipe. An unusually high amount of nonmetallic inclusions including manganese sulfides and aluminates were discovered throughout the pipe material. Non-metallic inclusions were also discovered along the weld seam region. The presence of these inclusions suggested low quality steel, a steel more prone to brittle failure.

Semi-Quantitative chemical analysis of one of the pipes suggested that the pipe was susceptible to failure. It was determined that the pipe was similar in composition to AISI-SAE grades 1006 and 1008 plain carbon steel except that the phosphorus and sulfur contents (0.11 and 0.058 respectively) were greater than the specified maximum allowable limits for these two grades of steel (0.040 max and 0.050 max respectively). As with the unwanted inclusions, the presence of these elements (phosphorous in particular) within the steel encouraged a more pronounced and severe brittle fracture failure. This is primarily due to a reduction in impact strength values that are often associated with excessive phosphorous contents.

Mechanical testing was performed on the pipe, which can be performed to establish material noncompliance. ASTM A370 specifications were used to determine the pipe's tensile properties including yield strength (0.2% offset), tensile strength, and elongation. The tensile properties were considered normal.

Given the test results, especially the presence of a brittle cleavage fracture, normal conditions did not cause the complete failure of the schedule 40 carbon steel pipe. The presence of mechanical damage within the thread roots suggests excessive loading and the mode of failure, brittle cleavage fracture, indicates a single, sudden overload event. A cross section of the layers of soil and backfill in the excavation trench at the location of failure revealed that one pipe section appears to have been sufficiently reinforced from underneath, while the adjoining pipe section was not. When several layers of concrete, asphalt, and brick backfill were applied to the unsupported pipe region to correct subsidence underneath the roadway surface, that portion of the pipe section was deflected downward and away from the fixed adjoining pipe section. The applied stress to the unsupported pipe section and the fixed position of the adjoining pipe section may have caused the pipe to

rupture at the adjoining pipe coupling as a result of these conditions. It was recommended that the soil subsidence problem be addressed and remedied.

