EGG-M-90012
CONF-900917--25

EGG-M--90012

DE91 001996

A METHODOLOGY FOR EXISTING SYSTEM UPGRADE TO CURRENT ASME STANDARDS AND SYSTEM LIFETIME EXTENSION

T. K. Burr
J. E. Dwight Jr.
G. L. Hawkes
N. E. Pace

January 1990

Idaho National Engineering Laboratory
EG&G Idaho, Inc.
P. O. Box 1625
Idaho Falls, Idaho 83415

Prepared for the U. S. Department of Energy
Idaho Operations Office
Under DOE Contract No. DE-AC07-76ID01570

A METHODOLOGY FOR EXISTING SYSTEM UPGRADE TO CURRENT ASME STANDARDS AND SYSTEM LIFETIME EXTENSION

In the wake of the Chernobyl events, there has been an increase in the awareness and review of government operated reactors both internationally, and within the United States. Government reactors have recently come under increased and indepth scrutiny. Department of Energy Secretary Hodel committed to a review of the safety of non-commercial reactors and irradiation facilities within the department. The increased attention has been in the areas of accident response, PRA of the facilities, environmental impacts, and the construction and associated standards for the facilities. This paper will focus on the system qualifications to current standards. Specifically, this paper discusses a method used for upgrading an existing high pressure nuclear system to current ASME Code standards and to extend the system's lifetime. This paper reports the methods used in an attempt to qualify components of the Advanced Test Reactor (ATR) located at the Idaho National Engineering Laboratory (INEL) to current ASME Code Section III standards.

ATR is a 250 MW_t light water low pressure reactor used for irradiation materials testing. ATR started operations 20 years ago. ATR was designed to provide the capability for high flux irradiation testing of various structural materials. The reactor core configuration is a four - lobe cloverleaf shape which is capable of flux shaping with different power in each lobe. There are nine positions for in-pile tubes which contain and locate the material specimens within the core. Each experimental loop is independent from the reactor, closed piping system consisting of the in-pile tube pressure tube assembly, interconnecting piping, and out-of-pile equipment (pumps, heaters, heat exchangers). The operating pressure of the in-pile tubes is approximately 2000 psi. The loop piping system is supported by a system of restraints consisting of rod hangers, spring hangers, constant force supports, and other structural members. Most piping components in the loops are 2- and 3-in. components. The test loops are used to demonstrate this methodology discussed in this paper.

The ATR experimental loop piping was originally constructed to satisfy the requirements of ASA B31.1 - 1955 and the supplemental requirements provided to the Manufacturer in the Owner / Operator's specification. The design conditions for the piping systems and associated equipment (valves, pumps, heat exchangers and pressurizer) were 2500 psig, 650°F and less than 7000 full pressure / temperature cycles over a 20 year lifetime. Operation of the loops began in August 1969. A number of modifications have been made to the systems and although operating conditions have varied, they have remained within the bounds of the basic design conditions. Early in the life of the system, however, it was recognized that newer standards and analysis methods were being developed. New conditions to be examined were thermal transients from fluid mixing at intersections and dynamic loads from earthquakes and postulated blow down forces. The new rules of Section III of the ASME Boiler and Pressure Vessel Code are now available to facilitate qualification concerning the above items.

It is now desired to show that the loops meet Section III standards and extend the lifetime of this system from 20 years to 45 years. To do this, it is necessary to demonstrate that the system, as constructed and modified, meets all of the construction requirements of Section III and not just the design analysis requirements. The methodology developed to accomplish this task was based on the following:

(1) Review of Existing System Construction and Quality Assurance
(2) Develop Design Specification
(3) Comprehensive Thermal Analysis
(4) Stress / Seismic Analysis.

Review of Existing System

It is required that some degree of assurance that the fabrication and inspection procedures and practices used during system fabrication were equivalent to the ASME Code. This can generally be accomplished by comparing the applicable standards used with the ASME Code requirements in the fabrication and inspection areas. In those situations where the Section III requirements have not been satisfied or where the rules of Section III do not address the situation, a resolution will be developed which demonstrates that the intent of the Code has been or will be satisfied. Approval of this resolution will be obtained from a local INEL panel consisting of representatives of the four Section III parties (Owner, Manufacturer, Authorized Inspector, and Jurisdiction). The "intent of the Code" and the selection of the Code "parties" are defined.

Certified Design Specification

Existing specifications for older systems tend to be quite conservative, but normally contain little thermal transient detail. Detailed specifications are needed for system upgrade and lifetime extension purposes. Existing system operation records and the knowledge of long term employees were very valuable in writing the new specifications. The system history was reviewed and reduced to a set of pressure and thermal transient conditions that realistically represent the past operation. Future operation must be estimated based on known operation plans allowing as much flexibility as possible without creating unacceptable thermal conditions. Detailed specifications were created for each separate system which represented the most accurate operating history possible with the information available.

The detail thermal transient information in the specification allows the analyst to select and group the thermal transients such that the minimum number of thermal transients are actually analyzed. The most severe thermal transient of each group was analyzed and the full number of cycles considered.

Areas where the most significant thermal transients occur are given the most attention in developing the specification. This provides the most accurate lifetime prediction for the most critical components. A detailed analysis based on the detailed specification also provides the information needed to extend component lifetimes later by reducing the expected number of thermal transients to the actual number experienced.

System Analysis

In order to predict the lifetime of each component, thermal and stress analyses were performed for piping components within the loop. Finite element models of the various components were created. The transient heat conduction in the piping components was solved by the finite element code ABAQUS. The thermal transients developed in the specification were implemented in the ABAQUS models by calculating a water film temperature and heat transfer coefficient as a function of time by using acceptable heat transfer correlations in piping components. The thermal gradients DT1, DT2, and DT3 as prescribed by ASME Code section NB-3600 were then calculated from the ABAQUS output. These DT values are then used in the systems piping code NUPIPE to calculate the thermal stresses induced in a piping component due to axial or radial temperature differences. NUPIPE calculates a usage factor for each piping component taking into account weight, thermal, pressure, and seismic loadings, supporting constraints and the number of times each transient occurs for a given component.

When considering only seismic loading, it is desirable to restrain the loop piping from moving during seismic events. There exists, however, a fine line of how much restraint to impose on a piping system when considering thermal expansion, pressure loads, and seismic loads combined together. Overly restraining a system for seismic loads may tend to overstress the system when thermal expansion occurs due to normal reactor heatup. It is important to consider all of these factors when adding additional supports for seismic loads.

Similar components and transients were conservatively grouped together in order to reduce the computer runs. For example, if a component undergoes fifteen transients, the seven most severe would be analyzed. The other eight would be covered by the seven that were analyzed by increasing the number of times that each transient occurs. This greatly reduced the complexity of the analysis and computer usage.

Conclusions

A detailed specification was a significant undertaking, but doing the analyses for the many thermal transients allows individual component usage factors to be calculated. Maximum lifetimes can then be obtained by analysis of past operation along with future operating history to reduce the fatigue usage factors. Most components can experience the 45 yr lifetime without exceeding the usage factor, but some components do have less than the 45 yr lifetime. Design changes and/or component periodic replacement are required to obtain the full 45 yr lifetime desired for these systems. The lifetimes can also be extended by subtracting significant thermal transients expected and included in the analysis that were not experienced during the component's lifetime.

- END -

DATE FILMED

11 / 29 / 90