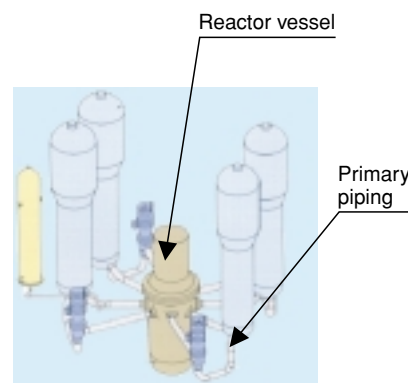


Technology to Assess the Integrity of Components for Nuclear Plants

Background and Objective

The reactor vessel and the primary piping of a nuclear power plant that have been operated for a long period are possible to be embrittled due to radiation and high temperature during operation, and the safety-related electric cables are also possible to be degraded. And, the reactor vessel and the piping in the primary water tend to cause fatigue cracks earlier than in air. Particularly, the weld zone with a high residual tensile stress has potential to cause accelerated fatigue crack initiation and growth. Therefore the objectives of this research is to establish the method to evaluate the degree of embrittlement and degradation due to the irradiation and high temperature during operation, and to establish the method to evaluate the initiation and growth of fatigue cracks under the reactor water environment.



Example of PWR Plant

Features



Fatigue Test Facility under the simulated Reactor Water Environment

The acceleration test for degradation of aged components and piping of a nuclear plant is conducted assuming operation of 60 years. For the irradiation test, radiation doses and the temperature in the reactor are simulated in a research reactor or a post-irradiation test facility (hot laboratory). And for the reactor water environment test, the water quality, temperature and pressure of the reactor water are also simulated. Also, the residual stress in the weld zone of components and piping is measured and verified using the full-scale mock up.

Schedule

Subjects \ Fiscal Year	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	Project
Evaluation of Environmental Fatigue	[Orange bar]														FET	
Evaluation of Embrittlement						[Orange bar]									PLIM	
Evaluation of Residual Stress in Welded Structures								[Orange bar]								IAF
Evaluation of Aging cables									[Orange bar]							ACA

FET : Environmental Fatigue Tests of Nuclear Power Plant Materials for Reliability Verification
IAF : Integrity Assessment of Flawed Components with Structural Discontinuity

PLIM: Nuclear Power Plant Integrated Management Technology
ACA : Assessment of Cable Aging for Nuclear Power Plant

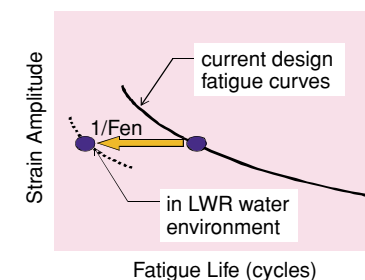
Future Deployment

Technologies to reuse the used test pieces to monitor the neutron embrittlement of the reactor vessel, and the method to evaluate the thermal embrittlement of the primary piping, the degradation of cables and the fatigue effect in the reactor water environment on the materials will be established. These technologies will be reflected in the integrity assessment of aged plants. In order to enhance the accuracy of the assessment, the data of fatigue crack growth rates in the reactor water environment and the method to evaluate the residual stress of complicated geometries will also be established.

Topics

Evaluation of Environmental Fatigue

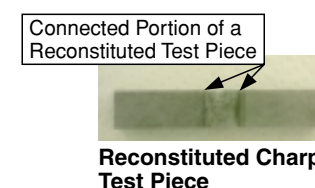
- The environmental fatigue correction factor F_{en} , which specifies the degradation rate of the fatigue life in reactor water environment compared with those in air, has been formulated. Parameters to calculate the fatigue factor F_{en} are strain rate of loading, temperature, water quality and materials. Development of the technical guideline taking account of the actual load fluctuation and the change of reactor water environment is in progress in addition to other various verification tests.



The environmental Fatigue correction Factor F_{en} indicates the degree of reducing the fatigue life in reactor water environment.

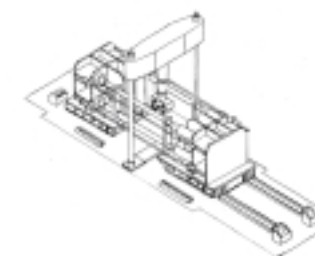
Evaluation of Embrittlement

- For the long operation of a nuclear plant, it is concerned that test pieces will be in shortage that are used for monitoring the degree of neutron irradiation embrittlement. Therefore, the test to establish the technique to reconstitute test pieces from the used test pieces are underway.



Reconstituted Charpy Test Piece

- The destructive tests of large diameter pipings, which are thermally embrittled simulating 60 years operation are underway.



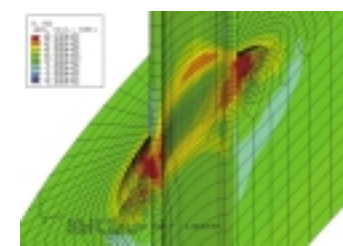
Destructive Test Facility for Large Diameter Piping

Evaluation of Residual Stress in Welded Structures

- Welding residual stresses are measured with the test piece simulating actual welding conditions and actual joint geometries. The stress is also calculated by the thermal elastic-plastic finite element analysis. The analytical model is verified by evaluating both results of analysis and measurement of mock up weldment.



Mock-Up for Bottom Mounted Instrument Penetration Weldment



Finite Element Model for Vessel Penetration

Evaluation of Aging Cables

- Safety-related electric cables for nuclear power plant is essential to maintain their function, even if the cables were subjected to the LOCA environment at the end of operating period (60 years). The integrity of various safety-related cables has been verified by evaluating the result of the aging cables obtained from the simultaneous aging test with thermal and radiation that simulates more precisely the actual cable aging, and by testing the simulated environment of LOCA with aged cables.



Simultaneous Aging Test Facility for cables