



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATING TO SEISMIC QUALIFICATION OF CABLE TRAY/SUPPORTS

TENNESSEE VALLEY AUTHORITY

BROWNS FERRY NUCLEAR PLANT, UNIT 2

DOCKET NO. 50-260

1.0 BACKGROUND

Concerns have been raised over Browns Ferry Nuclear Plant (BFNP) cable tray overfill and excessive application of fire retardant material (flamemastic). In order to address these concerns and concerns in general with the cable tray/supports in the BFNP, the Tennessee Valley Authority (the licensee or TVA) embarked on a program to evaluate the cable tray/supports at Unit 2. The evaluation included review of all supports in Units 1, 2 and 3 essential to Unit 2 and non-essential supports in Units 1, 2 and 3 whose failure could effect systems or components essential to Unit 2. An interim acceptance criteria was developed by the licensee for the reevaluation of the tray/supports, in terms of their capability in maintaining structural integrity and functionality during and after a Design Basis Earthquake (DBE). A combination of field walkdowns and calculations for critical supports was used to evaluate the cable tray/supports.

Cable trays and supports in Units 1, 2 and 3 were evaluated by the licensee based on the interim acceptance criteria, as required, to assure that cable essential to Unit 2 would be available during and after a DBE. This required that cable tray/supports in Units 1 and 3, which are essential to Unit 2, be included in the scope of the short term or interim program. The areas that were evaluated during Phase I of the program included:

- Common Pumphouse
- Common Electrical Tunnel
- Units 1, 2 and 3 Cable Spreader Room
- Units 1, 2 and 3 Diesel Room
- Unit 2 Reactor Building (E1. 565 and 593)
- TVA identified portions of the Units 1 and 3 Reactor Buildings at E1. 565 and 593.

Phase 2 of the program was later initiated by the licensee to evaluate the effect of non-essential cable tray/supports on systems and components essential to Unit 2. Additional essential cable tray/supports which are potentially essential to Unit 2 were also included. The areas that were evaluated during Phase 2 of the program included:

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- Remaining trays in Units 1 and 3 Reactor Building at E1. 565 and 593
- Units 1, 2 and 3 Reactor Buildings (E1. 621.25 and 639)
- Unit 2 Drywell
- Units 1, 2 and 3 Battery Board Rooms
- Units 1, 2 and 3 Auxiliary Instrument Rooms
- Units 1 and 2 (Common) and Unit 3 Computer Rooms
- Off Gas Treatment Building (Common)

Field inspections were conducted to establish weights of cable trays/conduits, to confirm the existence of proper load paths and to establish that supports have been generally located consistent with original design criteria. TVA field inspection of the Unit 3 Cable Spreader Room was utilized for determination of the most critical condition in this location. The field inspections were also intended to identify the most critical cases for further evaluation. Clearances in the vicinity of flexible supports were evaluated to ensure that potential impacts on critical systems and components did not compromise their intended functions. Also, potential displacements were reviewed to assure that cable integrity was not affected. Calculations were performed for critical combinations of load and support configuration/spacing. On the basis of the above, fourteen modifications were found necessary where the Interim Acceptance Criteria were not satisfied.

2.0 EVALUATION

The Interim Acceptance Criteria presented in the licensee's submittal of May 2, 1986 were the bases for the BFN cable tray/support evaluation. In addition to providing the evaluation techniques and acceptance criteria for the flexible and rigid supports, they also provided information regarding the field inspections which preceded the detailed support evaluation.

For purposes of classification, the term flexible support is intended to denote trapeze type supports existing in the Reactor Building. Flexible supports are characterized by a minimum interaction between the horizontal and vertical effects on the support. Since the vertical support to the tray is provided by rods, horizontal movement of the tray will not produce significant prying or other vertical effects which could compromise the vertical load resisting capability of the support. Rigid supports are intended to denote all other supports in the plant where there is horizontal and vertical interaction. Examples of these supports are those found in the Spreader Room, Pumphouse, Diesel Building and Tunnel.



Loads and Load Combinations

The loads considered in this interim reevaluation are dead loads and DBE. Dead loads in lb/ft were established in the field walkdown. Accelerations for the DBE were established by multiplying the spectral acceleration for the Operating Basis Earthquake (OBE) by two except for higher elevations in buildings such as the Control Bay, Drywell and Reactor Building where a factor of 1.5 is permitted. Horizontal acceleration response spectra are given for the OBE at various elevations throughout the plant. The vertical spectral acceleration response has been established as 2/3 of the ground horizontal acceleration response spectra. This is acceptable in light of the original licensing commitment of the plant as defined in the BFN FSAR.

The load combination considered are dead loads plus DBE (vertical and one horizontal direction). Because the cable tray/support motions are generally confined in vertical planes and, in effect, have been so analyzed, the method of combining the effects of vertical and horizontal earthquakes by the square root of the sums of the squares is found to be acceptable.

Acceptance Criteria

The criteria established by the licensee consisted of a combination of Code allowable forces, stresses and displacements as outlined in their May 2, 1986 submittal. Allowables were selected so that structural integrity would be maintained throughout the cable tray/support systems in the event of a DBE. This insures operability of the safety related systems. Allowables for the tray and tray/support connection were based on force/stress limits. Allowables for flexible-trapeze type supports were based on displacement limits. Allowables for the lateral restraints, which provide lateral stability to flexible supports, were based on force/stress limits. Finally, allowables for rigid hangers were based on a combination of force/stress and deformation limits. For cases where excessive deformation could produce impact on critical components, clearances were also evaluated. In addition, effects of deformation on cable integrity were evaluated.

1. Tray

For trays on flexible supports, the vertical load carrying capability is adequate provided the span length between vertical supports is less than or equal to 8 feet and the tray weight is less than 75 lb/ft. The horizontal transverse load carrying capability of trays is adequate if the span lengths between lateral restraints is 50 feet or less and the average weight of stacked trays is less than 75 lb/ft. This is consistent with the intent of the original design and is acceptable. Horizontal longitudinal capability of trays are implicitly qualified because of the adequate transverse load carrying capability.



For trays on rigid supports, the vertical and horizontal transverse load carrying capability is adequate if the span length between supports is less than or equal to 8 feet and the tray weight is less than 75 lbs/ft. Horizontal longitudinal load carrying capability of trays are implicitly qualified provided adequate load paths exist.

The above criteria are found to be acceptable by the staff.

2. Effect of Displacement

Critical items in the vicinity of cable trays with flexible supports were noted in walkdowns and were evaluated to insure that displacements are within acceptable limits.

For flexible supports, no vertical displacement check is required because displacements are negligible. However, in the horizontal directions (transverse and longitudinal), the following clear distances are required between trays and active and/or pressure boundary components, essential for Unit 2, to prevent impact:

- Transverse
 - 2 ½" for tray at the same elevation
 - 5" for tray with vertical offsets
- Longitudinal
 - 2 ½" for tray with substantial longitudinal restraint
 - 5" for tray without substantial longitudinal restraint
 - 5" for tray with vertical offsets.

Active components are defined as electrical cabinets and instrumentation. Pressure boundary components are defined as pumps, valves, piping and tubing. Also, conduits were addressed if supports are adjacent to the point of impact. In addition, it was established by the licensee that sufficient flexibility existed for cables entering and exiting the trays to accommodate the postulated tray displacement. This was verified for cables both inside and outside of conduit. Conduits longer than two feet and attached to a rigid cabinet are satisfactory provided that they are free to rotate at each end. The effect of shorter lengths was also evaluated by the licensee to determine if the functionality of equipment could be impaired. The above evaluation criteria are found to be acceptable by the staff.

For rigid supports no vertical or horizontal transverse displacement checks are required because the displacements are negligible, and it was verified in the field walkdown that sufficient longitudinal load paths (through bolted hold down clips) indeed existed to restrain the system. These above cited evaluations criteria utilized by the licensee are found to be acceptable by the staff.



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3. Tray-to-Support Connection

Two types of tray-to-support connections have been identified in the plant; bolted hold-down clips and bolts with oversized washers.

Vertical Connections: Since these connections provide only horizontal restraint and the dead weight is always larger than vertical seismic loads, no evaluation needs be performed for vertical connectors.

Horizontal Transverse (connections):

Bolts hold-down clips - For flexible supports, the rod hangers restrain the trays in the transverse direction in the event hold down clip capacity is exceeded. The capacity of the rod hanger was evaluated for its adequacy by the licensee. For rigid supports, the bolted hold down clips are used.

Bolts with oversized washers - For flexible supports the allowable stress per bolt in shear is taken as 62% of $0.7 F_u$, or $0.43 F_u$; where F_u is the ultimate tensile stress of the bolt.

Horizontal Longitudinal Connections: For flexible supports, longitudinal loads were assumed to be taken through branch points, tees and elbows and transferred to transverse supports as additional lateral loads. During the field walkdown it was determined if adequate load transfer mechanism was indeed available. When necessary, the longitudinal deflection was evaluated to determine the adequacy of the supports. For rigid supports, the bolted hold down clips are used to transfer the load in a longitudinal direction. The capacity of the clips has been determined to be 1,000 lbs. per pair of clips.

The staff has determined that the licensee's tray-to-support connection acceptance criteria described above are acceptable.

4. Supports

For flexible trapeze type supports the vertical load carrying capability is adequate provided the space length between supports is equal to or less than 8 feet and the average of all stacked tray weights is less than 75 lb/ft.

The lateral load carrying capability of flexible trapeze-type supports and the overall load carrying capability of rigid supports were evaluated by the licensee to the following acceptance criteria:



- (1) For structural steel (including welding) covered by the AISC (American Institute of Steel Construction) manual, the allowable forces and stresses may be increased by the lesser of a factor of 2 or 0.7 times the ultimate force/stress except for the following. The allowable shear stress in bolts is equal to $0.43 F_u$; where F_u is the ultimate tensile stress of the bolt.
- (2) For items which are designed using catalog values, such as expansion anchors, the allowable force/stress is equal to 0.5 times the ultimate force/stress.

Based upon the above, the allowable force/stress criteria as proposed by the licensee are found to be acceptable.

Evaluation Results

It should be noted that the evaluation of the supports includes the load transfer mechanism from the support to the restraint, the restraint itself, and the connection of the restraint to structure (surface mounted plate, embedded plate, bolts, expansion anchors, welds, etc.).

The plant walkdown inspections were conducted following the acceptance criteria as outlined above. An attempt was made to identify the most critical cable trays or supports for each zone. This resulted in a combination of the most critical loading and the most questionable tray/connection/support.

Subsequent to the plant walkdowns, calculations were performed by the licensee for the critical supports identified.

The staff has reviewed the calculations provided in the licensee's submittal of May 2, 1986. The frequency calculations are found to yield conservative estimate of the support natural frequencies, which in some cases fall in the region of floor spectrum amplification. This is based upon the fact that the input loads are found to be adequate with the use of a 1.2 factor which accounts for a possible multi-mode response. For the simple frame structures encountered, the natural frequencies are generally well separated to have little multi-mode effect. The calculations for responses and response combination due to different directions of earthquake input are also found to provide an adequate safety margin.

And, finally, adequate safety margins are seen to exist when compared with the interim acceptance criteria, with the exception of 14 modifications in the support design which need to be completed in order to meet the acceptance criteria.



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3.0 CONCLUSION

On the basis of the staff evaluation as presented in the above, the licensee's interim acceptance evaluation of the Unit 2 cable tray/supports is found to be acceptable. The plant restart should be permitted pending the licensee's confirmation of the completion of the 14 modifications on tray/supports and the licensee's verification that they have met the interim acceptance criteria after the modifications.

The long term evaluation of the Browns Ferry cable tray/supports seismic qualification will be covered under the A-46 program.

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