Apr. 5, 1982

CONSUMERS POWER COMPANY (C. P. CO.)
MIDLAND PLANT UNITS 1 & 2
STRUCTURAL ENGINEERING BRANCH
DOCKET NOS. 50-329 & 50-330

SAFETY EVALUATION REPORT

3.3.1 Wind Design Criteria

All Category I structures exposed to wind forces are designed to withstand the effects of the design wind. The design wind specified has a velocity of 85 mph based on a recurrence interval of 100 years.

The procedures that are used to transform the wind velocity into pressure loadings on structures and the associated vertical distribution of wind pressures and gust factors are in accordance with ASCE Paper No. 3269. This document is acceptable to the staff as identified in Section 3.3.1 of the Standard Review Plan.

The procedures that are utilized to determine the loadings on seismic Category I structures induced by the design wind specified for the plant are acceptable since these procedures have been used in the design of conventional structures and proven to provide a conservative basis which together with other engineering design considerations assures that the structures will withstand such environmental forces.

The use of these procedures provides reasonable assurance that, in the event of design basis winds, the structural integrity of the plant seismic Category I structures will not be impaired and, in consequence, seismic Category I systems and components located within these structures are adequately protected and will perform their intended safety functions, if needed. Conformance with these procedures is an acceptable basis for satisfying, in part, the requirements of General Design Criterion 2.

3.3.2 Tornado Design Criteria

All Category I structures exposed to tornado forces and needed for the safe shutdown of the plant are designed to resist a tornado of 290 mph tangential wind velocity and a 70 mph translational wind velocity. A simultaneous atmospheric pressure drop was assumed to be 3 psi in 1.5 seconds. Tornado missiles, as identified in Section 3.5.1.4, are also considered in the design as discussed in Section 3.5 of this report.

The procedures that are used to transform the tornado wind velocity into pressure loadings are similar to those used for the design wind loadings as discussed in Section 3.3.1 of this report. The tornado missiles effects will be determined using procedures to be discussed in Section 3.5 of this report. The total effect of the design tornado on Category I structures is determined by appropriate combinations of the individual effects of the tornado wind pressure, pressure drop and tornado associated missiles. Bechtel Corp. Topical Report BC-TOP-3A was the major reference used as design criteria. This reference report has been accepted by the staff and has been used in other reviews.

Structures are arranged on the plant site and protected in such a manner that collapse of structures not designed for tornados will not effect other safety-related structures.

The procedures utilized to determine the loadings on structures induced by the design basis tornado specified for the plant are acceptable since these procedures provide a conservative basis for engineering design to assure that the facilities structures withstand such environmental forces. The staff has identified clear conservatism for Diesel Generator Building and the Service Water Pump Structure. The applicant has provided partial

venting of these structures but has not used a reduced pressure load in their design.

The use of these procedures provides reasonable assurance that in the event of a design basis tornado, the structural integrity of the plant structures that have to be designed for tornados will not be impaired and, in consequence, safety-related systems and components located within these structures will be adequately protected and may be expected to perform necessary safety functions as required. Conformance with these procedures is an acceptable basis for satisfying, in part, the requirements of General Design Criterion 2.

3.4.2 Water Level (Flood) Design Procedures

The design flood level resulting from the most unfavorable condition or combination of conditions that produce the maximum water level at the site is discussed in Section 2.4, Hydrology. The hydrostatic effect of the flood will be considered in the design of all Category I structures exposed to the water head.

The procedures utilized to determine the loadings on seismic Category I structures induced by the design flood or highest ground-water level specified for the plant are acceptable since these procedures have been used in the design of conventional structures and proven to provide a conservative basis which together with other engineering design considerations assure that the structures will withstand such environmental forces. These procedures satisfy the guidelines identified in Section 3.4.2 of the Standard Review Plan.

The use of these procedures provides reasonable assurance that in the event of floods or high groundwater, the structural integrity of the plant

seismic Category I structures will not be impared and, in consequence, seismic Category I systems and components located within these structures will be adequately protected and may be expected to perform necessary safety functions, as required. Conformance with these design procedures is an acceptable basis for satisfying, in part, the requirements of General Design Criterion 2.

However, the applicant has not established the effectiveness of the groundwater-well-system. These wells are needed to control the groundwater level and prevent soil-liquefaction. The above conclusions are subject to the final approval of the wells that are designed to prevent a groundwater level that may cause soil-liquefaction of the fill, soil material supporting some Category I structures.

3.5.3 Barrier Design Procedures

The plant Category I structures, systems and components are shielded from, or designed for, various postulated missiles. Missiles considered in the design of structures include tornado generated missiles and various containment internal missiles, such as those associated with a loss-of-coolant accident.

Information has been provided indicating that the procedures that are used in the design of the structures, shields and barriers to resist the effect of missiles are adequate. The analysis of structures, shields and barriers to determine the effects of missile impact is accomplished in two steps. In the first step, the potential damage that could be done by the missile in the immediate vicinity of impact is investigated. This is accomplished by estimating the depth of penetration of the missile into the impacted structure. Furthermore, secondary missiles will be prevented by fixing the target thickness well above that determined for penetration. In the

second step of the analysis, the overall structural response of the target when impacted by a missile is determined using established methods of impactive analysis. The equivalent loads representing the missile impact, whether the missile is environmentally generated or accidentally generated within the plant, are combined with other applicable design loads as is discussed in Section 3.8 of this report.

The procedures utilized to determine the effects and loadings on seismic Category I structures and missile shields and barriers induced by design basis missiles selected for the plant are acceptable since these procedures provide a conservative basis for engineering design to assure that the structures or barriers are adequately resistant to and will withstand the effect of such forces. Bechtel Corp. Topical Report BC-TOP-9A was the major reference used as design criteria. This reference report has been accepted by the staff and has been used in other reviews.

The use of these procedures provides reasonable assurance that in the event of design basis missiles striking seismic Category I structures or other missiles shields and barriers, the structural integrity of the structures, shields, and barriers will not be impaired or degraded to an extent that will result in a loss of required protection. Seismic Category I systems and components protected by these structures are, therefore, adequately protected against the effects of missiles and will perform their intended safety function if needed. Conformance with these procedures is an acceptable basis for satisfying, in part, the requirements of General Design Criteria 2 and 4.

3.7.1 Seismic Input

The input seismic design response spectra /Operating Basis Earthquake (OBE) and Safe Shutdown Earthquake (SSE)7 applied in the design of seismic Category I structures and components were developed by scaling the Housner-developed response spectra to the appropriate peak acceleration values established for the site. The seismic responses used for the design in the period ranging from .2 to .6 seconds were increased by 50% to compensate for the differences between the site design response spectra (Housner-developed) and the Newmark-developed response spectra. The vertical design response spectra are defined by multiplying the horizontal site design response spectra by two-thirds. The site design response spectra are applied at the foundation level of seismic Category I structures.

The Midland design response spectra differ from Regulatory Guide 1.60, "Design Response Spectra for Nuclear Power Plants". These spectra (OBE and SSE) corresponded to a maximum horizontal ground acceleration of .06 g for OBE and .12 g for SSE. However, a new site specific response spectra has been identified for the Midland NPP site as identified in Section 2.5.2 (Vibratory Ground Motion). This site specific spectra will apply for the SSE while the OBE level will reflect previous commitments.

The specific percentage of critical damping values used in the seismic analysis of Category I structures, system, and components differ with Regulatory Guide 1.61, "Damping Values for Seismic Analysis of Nuclear Power Plants." These values are lower than those in Regulatory Guide 1.61. An analysis performed using these damping values and an acceptable spectrum would produce conservative results.

The synthetic time history used for the seismic design of Category I structures, systems and components is adjusted in amplitude and frequency con-

tent to obtain response spectra that envelop the corresponding response spectra specified for the site.

The applicant has provided to the staff an evaluation determining that the use of their modified Housrer response spectra used in conjunction with the conservative damping values identified in the FSAR provide similar design margins as those resulting from the use of the R.G. 1.60 response spectra used in conjunction with R. G. 1.61 damping values. However, the applicant has not yet evaluated the Category I structures for the effects of the new site specific response spectra identified in Section 2.5.2 of this Safety Evaluation Report. The staff requires that a safety margin evaluation be performed for all Category I structures.

3.7.2 & 3.7.3 <u>Seismic System and Subsystem Analysis</u>

The scope of review of the Seismic System and Subsystem Analysis for the plant included the seismic analysis methods for all Category I structures, systems and components. It included review of procedures for modeling, seismic soil-structure interaction, development of floor response spectra, inclusion of torsional effects, evaluation of Category I structure overturning, and determination of composite damping. The review has included design criteria and procedures for evaluation of interaction of non-Category I structures and piping with Category I structures and piping and effects of parameter variations on floor response spectra. The review has also included criteria and seismic analysis procedures for reactor internals and Category I buried piping outside the containment.

The evaluation of Category I buried piping for the effects of the soil settlement has been performed by MEB.

The system and subsystem analyses were performed by the applicant on an elastic basis. Multidegree-of-freedom response spectrum and time history methods using the principle of modal superposition form the basis for the analyses of all major Category I structures, systems and components. When the response spectrum method was used, modal responses of governing response parameters were combined by the square root of the sum of the squares rule. However, the absolute sum of the modal responses was used for modes with closely spaced frequencies. The square root of the sum of the squares of the maximum codirectional responses was used in accounting for three components of the earthquake spectra inputs used for design and test verifications of structures, systems and components were generated from the time history method taking into account variation of parameters by peak widening. A verticial seismic system dynamic analysis was employed for all structures, systems and components where analysis show significant structural amplification in the vertical direction. Torsional effects and stability against overturning were considered.

The lumped soil spring approach was used to evaluate soil-structure interaction and structure to structure interaction effects upon seismic responses.

Due to the existing soil conditions at Midland site the applicant has committed to remodel the structures effected by the fill material supporting them to represent and consider the soil parameters for the life of the plant, the settlement parameters and any new changes to the various Category I structures founded on fill. The information on the dynamic models has been discussed and reviewed during the hearings, thru testimonies, and other regular docketed information. There is general agreement on the approaches

and results of these analyses. However, final disposition for all of the Category I structures effected by the soil conditions is still pending. In addition, as stated in Section 3.7.1 of this report the Safety Margin's evaluation utilizing the Site Specific Response Spectra is still an open item, pending submittal of information by the applicant. The applicant has made an attempt to design new structures (i.e. BWST Foundation Rings, Underpinning for Aux. Bldg. and SWPS) to values of 1.5 FSAR spectra values. However, the applicant needs also to demonstrate that the floor response spectra resulting from this scaling approach will envelop floor response spectra derived from the site specific response spectra for all applicable damping values and structural frequencies.

3.7.4 Seismic Instrumentation Program

The type, number, location and utilization of strong motion accelegrographs to record seismic events and to provide data on the frequency, amplitude and phase relationship of the seismic response of the containment structure comply with Regulatory Guide 1.12. Supporting instrumentation is also being installed on Category I structures, systems and components in order to provide data for the verification of the seismic responses determined analytically for such Category I items. These instruments comply with Regulatory Guide 1.12.

The installation of the specified seismic instrumentation in the reactor containment structure and at other Category I structures, systems, and components complies with Regulatory Guide 1.12 and constitutes an acceptable program to record data on seismic ground motion as well as data on the frequency and amplitude relationship of the response of major structures and systems. A prompt readout of pertinent data at the control room

can be expected to yield sufficient information to guide the operator on a timely basis for the purpose of evaluating the seismic response in the event of an earthquake. Data obtained from such installed seismic instrumentation will be sufficient to determine that the seismic analysis assumptions and the analytical model used for the design of the plant are adequate and that allowable stresses are not exceeded under conditions where continuity of operation is intended.

Compliance with the requirements of Regulatory Guide 1.12 satisfies the Structural Engineering Branch requirements identified in Section 3.7.4 of the Standard Review Plan.

3.8.1 Concrete Containment

The NSSS system is enclosed in a concrete containment (reinforced concrete base and prestressed concrete cylinderical wall) as described in Section 3.8.1 of the FSAR. The containment structure was designed in accordance with applicable codes, standards and specifications in use before April 1973. Designs and analysis performed after this date were designed in accordance with applicable subsections of the ASME Boiler and Pressure Vessel Code, Section III Div. 2, and the American Concrete Institute (ACI 318). Various combinations of dead loads, live loads, environmental loads including those due to wind, tornadoes, OBE, SSE, and loads generated by the design base accident including pressure, temperature and associated pipe rupture effects were considered. Since a majority of the containment design was completed by 1973, the load combinations used and presented in the FSAR do not agree with those in the staff Standard Review Plan (SRP) 3.8.1. The applicant has identified critical sections of this structure

and determined that adequate safety margins exist when using current staff acceptance criteria (ASME/ACI 359 in conjunction with SRP 3.8.1). However, based on the newly imposed site specific spectra the staff requires that the applicant perform a safety margins analysis for the containment building. Therefore this remains an open item.

Static analysis for the containment shell and base mat were based on methods previously accepted by the staff. Likewise, the liner design for the containment employed methods similar to those previously accepted by the staff.

The choice of the materials, the arrangement of the anchors, the design criteria and design methods are similar to those evaluated for previously licensed plants. Materials, construction methods, quality assurance and quality control measures are covered in the FSAR and, in general, are similar to those used for previously accepted facilities and are acceptable to the staff.

Prior to operation, the containment will be subjected to an acceptance test in accordance with the Regulatory Guide 1.18 during which the internal pressure will be 1.15 times the containment design pressure. This requirement is acceptable to the staff.

The criteria used in the analysis, design, and construction of the concrete containment structure to account for anticipated loadings and postulated conditions that may be imposed upon the structure during its service lifetime are in conformance with established criteria, codes, standards, guides, and specifications acceptable to the Regulatory staff. Resolution of the

open item related to the evaluation of the structure for the new site specific spectra will bring the design and analysis of the containment structure in full conformance with NRC established criteria.

The use of these criteria as defined by applicable codes, standards, guides, and specifications; the loads and loading combinations; the design and analysis procedures; the structural acceptance criteria; the materials, quality control programs and special construction techniques; and the testing and in-service surveillance requirements provide reasonable assurance that, in the event of winds, tornadoes, earthquakes and various postulated accidents occurring within the containment, the structure will withstand the specified design conditions without impairment of structural integrity of safety function. Conformance with these criteria, pending the resolution of the open item will constitute an acceptable basis for satisfying, in part, the requirements of General Design Criteria 2, 4, 16, and 50.

3.8.3 Concrete and Structural Steel Internal Structures

The containment interior structures consist of support systems (reactor, steam generator, coolant pump), reactor coolant pipe restraints, primary and secondary shield walls, pressurizer supports, refueling canal walls, operating and intermediate floors, missile shields, polar crane supporting elements, in core instrumentation tunnel and let down cooler enclosure. The containment concrete and steel internal structures were designed to resist various combinations of dead and live loads, accident induced loads, including pressure, jet loads, and seismic loads. Since the design of Category I internal concrete structures was completed before 1973, the load combinations presented in the FSAR are in accordance with ACI-318 and not with current NRC requirements. Specifically, the staff currently

uses as the acceptable reference ACI-349, modified as per Regulatory Guide RG 1.142. The applicant has identified critical sections and components and determined that adequate safety margins exist when using the current staff acceptance criteria (ACI-349 in conjunction with RG 1.142). The results of this evaluation were reviewed and found acceptable by the staff. However, due to the acceptance of the new site specific response spectra the applicant is committed to re-evaluate the internal structure for this variation in seismic environmental load. Therefore, this remains an open item. The load combinations for steel structures in FSAR 3.8.3 are in accordance with the AISC specification. The applicant fully follows these requirements in their design of Category I internal steel structures. Their use of the AISC Specifications for steel structures complies with the staff requirements for steel structures as identified in SRP 3.8.3. Via our 1981 memorandum and the IE Bulletin No. 80-11, the staff has requested that the applicant submit information on the use of masonry walls in Category I structures, their location, design and analyses methods, piping/equipment supports, and that he show compliance with SEB Criteria for Safety Related Masonry Walls Evaluation. Our final evaluation of this matter pends on the submittal of the requested information by the applicant. This remains an open item.

The original reactor vessel support system was determined to be inadequate based on the failure of a number of anchor bolts prior to the application of any design loads (other than pre-tension loads). A new reactor support system was proposed by the applicant and reviewed by the staff. This new support system consists of shear pins to transfer the torsional moment and shear loads at the reactor vessel base; anchor studs that provide resistance to overturning moments and uplift at the reactor vessel base; and upper

lateral support brackets that relieve the base from most of the overturning moment. The staff has concurred with this new design concept prior to its installation.

The criteria that is used in the design, analysis, and construction of the containment internal structures to account for anticipated loadings and postulated conditions that may be imposed upon the structures during their service lifetime are in conformance with established criteria, and with codes, standards, and specification acceptable to the Regulatory staff. Resolution of the open items related to the evaluation of the structures for the new site specific spectra and for the masonry walls will bring the design and analysis of the internal structure in full compliance with NRC established critera.

The use of these criteria as defined by applicable codes, standards, and specification; the loads and loading combinations; the design and analysis procedures; the structural acceptance critera, the materials, quality control programs, and special construction techniques; and the testing and in-service surveillance requirements provide reasonable assurance that, in the event of earthquakes and various postulated accidents occurring within the containment, the interior structures will withstand the specified design conditions without impairment of structural integrity or the performance of required safety functions. Conformance with these criteria, pending resolution of the open items, constitutes an acceptable basis for satisfying in part the requirements of General Design Critera 2 and 4.

3.8.4 Other Category I Structures

Category I structures other than the containment and its interior structure are all of structural steel, reinforced concrete and reinforced concrete block. The major Category I structures considered in this section include the Auxiliary Building and adjacent minor structures (i.e. FIVP), the Service Water Pump Structure, the Diesel Generator Building, the Borated Water Storage Tanks and their Foundation Support Rings, Other Buried Tanks and Ducts. All of these structures are part of the soil remedial action hearing and related staff review of re-analysis. The Auxiliary Building, FIVP and Service Water Pump Structure will be underpinned in the areas that support is provided by the soil fill. This construction technique will assure proper foundation support as good or better than the original design. The BWST foundation rings will be with adjacent rings capable of providing complete support for the tanks. In addition, Tank No. 1 which was effected by substantial differential settlement will be releveled prior to operation. The Diesel Generator Building has been surcharged to provide additional soil consolidation with approximately 20 feet of sand. The structural components consist of slabs, walls, beams, and columns. The major codes used in the design of concrete Category I structures are the ACI 318-63, ACI 318-71, "Building Code Requirements for Reinforced Concrete." For steel Category I structures, the AISC, "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings" is used.

These Category I structures were designed to resist various combinations of dead loads; live loads; environmental loads including winds, tornadoes, OBE and SSE, and loads generated by postulated ruptures of high energy pipes such as reaction and jet impingement forces, compartment pressures, and

impact effects of whipping pipes. Since the design of a majority of Category I structures was completed before 1973, the load combinations presented in the FSAR are in accordance with applicable codes and standards in use before this date. The load combinations for the concrete structures do not agree with the current NRC acceptance criteria. Specifically the staff uses as the acceptance reference ACI 349 modified by RG 1.142. The applicant has evaluated each of these structures at critical sections and determined that adequate safety margins exist when using the current staff acceptance criteria (ACI 349 in conjunction with RG 1.142). The results of this evaluation have been reviewed by the staff and found acceptable. In addition the applicant has committed to design all of the underpinning structures for the Auxiliary Building, FIVP, and the Service Water Pump Structure; including the foundation rings for the Borated Water Storage Tanks to current staff acceptance criteria. Also C. P. Co. has promised additional analyses for these structures and the Diesel Generator Building to assure the staff of their safety margins for CP and OL review loads. Therefore, these issues related to remedial soil actions remain an open item. For steel structures the AISC specification is found acceptable by the staff as identified in SRP 3.8.4.

The materials of construction, their fabrication, construction and installation are in accordance with the ACI 318-63, ACI 318-71 codes and the AISC specifications for concrete and steel structures respectively. However, the applicant has evaluated any deviation from ACI-349 as modified by R. G. 1.142 and determined that they have no significant effect on the safety of these concrete structures.

The extensive soil settlement has resulted in the related cracking of the concrete. This has been observed in various Category I structures. Additional details are provided in Section 3.8.5 of this report. The review of this problem area remains an open item.

The criteria that will be used in the analysis, design, and construction of all the plant Category I structures to account for anticipated loadings and postulated conditions that may be imposed upon each structure during its service lifetime are in conformance with established criteria, codes, standards, and specifications acceptable to the Regulatory staff. Resolution of the open items will bring the design and analysis of other Category I structure in full compliance with NRC established criteria.

The use of these criteria as defined by applicable codes, standards, and specifications; the loads and loading combinations; the design and analysis procedures; the structural acceptance criteria; the material, quality control, and special construction techniques; and the testing and in-service surveillance requirements provide reasonable assurance that, in the event of winds, tonadoes, earthquakes and various postulated accidents occurring within the structures, the structures will withstand the specified design conditions without impairment of structural integrity or the performance of required safety functions. Conformance with these criteria, codes, specifications, and standards pending resolution of the open items will constitute an acceptable basis for satisfying, in part, the requirements of General Design Criteria 2 and 4.

3.8.5 Foundations

Foundations of Category I structures are described in Section 3.8.5 of the FSAR. Primarily, these are reinforced concrete mat foundations. The

Diesel Generator Building is one of the major structures which utilizes footers instead of mat foundations. The major code use in the design of these concrete foundations is ACI 318-63 prior to 1973 and ACI 318-71 after 1973. These concrete foundations are designed to resist various combinations of dead loads; live loads; environmental loads including winds, tornadoes, OBE and SSE, and loads generated by postulated ruptures of high energy pipes.

The original design and analysis procedures used for Category I foundations are the same as those approved on previously licensed applications and, are in accordance with procedures delineated in ACI 318-63 and ACI 318-71 codes. The material of construction, their fabriaction, construction and installation are in accordance with ACI 318-63 and ACI 318-71 codes.

Extensive soil settlement and cracking in concrete walls have been observed in various Category I structures as result of diffential settlement and other construction loads. The structures affected include the Diesel Generator Building, the Service Water Pump Structure, Foundation for Borated Water Storage Tanks, the Buried Tanks and Ducts, the Feed-Water Isolation Pits and the Auxilliary Building. A detailed review of this problem area has taken place in the past two years. The applicant has proposed various remedial actions and provided different evaluations for staff review. From this process a conservative approach has developed to provide the appropriate remedial action for each of the above structures.

The applicant has committed to provide underpinning for structures with observed diffential settlement between parts of the same structure (Auxiliary Bldg & Service Water Pump Structure). This underpinning structural system will provide support of all parts of these structures on natural undisturbed natural material (glacial till) rather than partial support on the glacial till and the remainder on poor fill soil material.

The applicant has proposed and implemented a surcharge program for the structures receiving total soil support from the fill material (Borated Water Storage Tanks and Diesel Generator Building). The surcharge program has accelerated soil compaction, thus reduced future differential settlement and therefore it has developed a more predictable behavior of these structures during the 40-year life of the plant. For the BWST the applicant has committed to provide new foundation support rings in addition to the original foundation rings.

The applicant has been able to prove the adequacy of the Buried Oil Storage Tanks and Electrial Duct Banks by analyses and field measurement.

The applicant has agreed to provide both static and dynamic analyses for all of these structures utilizing corrected models to represent appropriate soil and structural parameters, including various stages of construction during the implementation of the various remedial actions for each of the structures. Also, the applicant has agreed to provide evaluations of these structures for identified and future crack mapping results and a program for epoxing all significant cracks.

The applicant has committed to design and construct the new underpinning and foundation structural systems to requirements that satisfy the staff current acceptance criteria (ACI-349 in conjunction with RG 1.142). Also the applicant has committed to evaluate all Category I structures for the new site specific spectra and determine the available safety margins for these structures, including their foundations.

The criteria that has and will be used in the analysis, design, and construction of all the plant Category I foundations to account for anticipated

loadings and postulated conditions that may be imposed upon each foundation during its service lifetime shows the applicant intent to comply with established criteria, codes, standards, and specifications acceptable to the NRC staff. Resolution of the open items will bring the design and analysis of Category I structures in full compliance with NRC established criteria.

The use of these criteria as defined by applicable codes, standards, and specifications; the loads and loading combinations; the design and analysis procedure; the structural acceptance criteria; the materials, quality control, and special construction techniques; and the testing and in-service surveillance requirements provide reasonable assurance that, in the event of winds, tornadoes, earthquakes and various postulated events, Category I foundations may withstand the specified design conditions without impairment to structural integrity and stability or the performance of required safety functions. Conformance with these criteria, codes, specifications, and standards, pending resolution of the open items, constitutes an acceptable basis for satisfying in part the requirements of General Design Criteria 2 and 4.

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