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mA/H

SUBJECT: Forwards addl info requested in NRC 800909 ltr re DYWIDAG threadbar sys.Approval of sys requested by 801201 to allow for use in structures scheduled for const beginning 810301. Lead time required to get needed matls & train splicers.

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N M NIAGARA MOHAWK

NIAGARA MOHAWK POWER CORPORATION/300 ERIE BOULEVARD WEST, SYRACUSE, N.Y. 13202/TELEPHONE (315) 474-1511

October 28, 1980

Mr. Robert L. Tedesco, Assistant
Director of Licensing
Division of Licensing
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Tedesco:

Re: Nine Mile Point Unit 2
Docket No. 50-410

Enclosed is the additional information requested in your letter of September 9, 1980 regarding the DYWIDAG Threadbar System. The review and approval of the DYWIDAG Threadbar System for use in safety related structures is requested by December 1, 1980. This would allow for its use in safety related structures scheduled for construction beginning March 1, 1981. This lead time is required to procure needed materials, establish Quality Assurance/Quality Control procedures and train splicers.

Very truly yours,

NIAGARA MOHAWK POWER CORPORATION

Gerald K. Rhode
Vice President
System Project Management

PEF:ja
Enclosure

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Response to NRC Request for Additional Information
Regarding the DYWIDAG Threadbar Reinforcing Steel System

Q 1. Provide the following information regarding the test data which you submitted by letter dated June 17, 1980.

a) The total number of specimens tested for each bar size. Discuss whether there were rejections of any test results and indicate the reasons for the rejections.

b) The test data submitted applies to the splices which use hex nuts. Discuss the other two types of splices.

c) From the test data submitted, we observed that the ultimate strength of the spliced specimen is generally less than the unspliced specimen. Discuss the reason for this behavior, the splice-bar interaction effects, and the immplications and interpretations of such behavior.

d) We also noticed that spliced specimens demonstrate a softening effect at the yield level when compared to unspliced specimens. Discuss the reasons, interpretation, and implications of such behavior.

e) Provide a description and interpretation of the failure mode of each specimen.

f) Provide a statistical description of the test data, such as confidence levels for ultimate strength and the amount of data scatter.

Response

a) In total, about 1,500 tests have been performed on the Grade 60 threadbar splice system. From tests performed in the United States, the following test records are available:

20 tests on No. 6 bar splice
34 tests on No. 7 bar splice
30 tests on No. 8 bar splice
26 tests on No. 9 bar splice
30 tests on No. 10 bar splice
39 tests on No. 11 bar splice
15 tests on No. 14 bar splice
23 tests on No. 18 bar splice

From these tests, 13 show substandard results with the failure load between 0.5 and 8.5 percent below the required load capacity. In most of these cases, the couplers had been reamed out on purpose beyond the maximum allowed tolerance range to evaluate the effect of a grossly undersized bar. Normally, bars like these would be rejected at the mill.

The tests performed by the mills using regular production couplers and bars have always passed the minimum load requirements.

b) A description of the three types of splices is given on page 5 of the system presentation submitted on June 17, 1980. The important parameters for determining the carrying capacity are the dimensions, material properties of bar and coupler, and the engagement length. All of these factors are identical for the three types of splices and, consequently, the carrying capacity is the same. The lock or hex nuts are only a means to introduce a torque moment and consequently, a preload in the coupler for slip reduction. The nuts do not have any influence on the carrying capacity. This is demonstrated by the fact that at a load of about 80 percent of the yield strength, the nuts are not in contact with the coupler and are loose on the bar.

Besides locking the coupler in position, torquing seats the bar thread deformations snugly into the coupler threads, thus reducing the slip, (i.e., plastic deformations under load). The more directly the torque is applied to the coupler-bar system, the more effective it is. In the case of the qualification tests submitted on June 17, 1980, full hex nuts have been used which, because of their length, have the most friction. Consequently, the preloading in the coupler is less effective when torquing hex nuts compared to torquing the shorter lock nuts or the bars directly.

In summary, splices using no nuts or lock nuts carry the same tensile loads with a smaller slip than splices using hex nuts.

c) The DYWIDAG threadbar splice is designed to carry the minimum ultimate strength specified by ASTM A615 for the bar material under the most unfavorable tolerance conditions. It was not designed to exceed the minimum ultimate strength in all cases. As explained on page 11 of our June 17, 1980 submittal, all qualification tests were performed with the testing materials prepared in such a way that artificially, the most unfavorable tolerance combination for the dimensions and engagement length had been created. All the splices still met the minimum required strength, but not necessarily the actual breaking strength of the bar. Of course, the load capacity of the splice increases when these most unfavorable conditions do not exist, as in regular production splices.

The failure mode of a splice that does not reach the actual breaking strength of the bar is such that the bar ribs shear off the threads in the coupler and then the bar slips out of the coupler. As pointed out above, more favorable tolerances and better engagement will increase the area of contact between bar and coupler threads, and thus increase the carrying capacity of the splice considerably beyond the minimum required load.

d) The softening effect is a very common phenomenon in all types of connections. It is caused by deformations in the coupler threads under load at the DYWIDAG threadbar splice. Initially, the splice is preloaded by the torque moments to seat the bar deformations snugly into the coupler threads to preeliminate part of the slip. With increasing load, the effect of the preload is decreased until it

d) (cont.) becomes zero. At this point, the bar deformations start to seat into the coupler threads causing very small plactic deformation. These add up with the elastic elongation under load, causing the load elongation curve of the spliced sample to deviate from the one of the unspliced sample. The difference in elongation is called slip, but actually is a plastic deformation. Under ACI Standard No. 349-76, a slip of 50 percent of the elongation of an unspliced bar at 90 percent of yield is allowed for unstaggered splices. An undefined higher slip can be permitted for staggered splices. The slip for the DYWIDAG threadbar splices at 90 percent of yield stays below the 50 percent requirement of ACI 349.

As the load increases beyond 90 to 100 percent of yield, seating of the bar deformations into the coupler threads increase at a faster rate than before, causing the rounded transition section in the load-elongation curve, but stabilize again after exceeding the yield strength of the bar. The amount of plastic elongation in the coupler threads depends on the dimensional tolerances, engagement between bar and coupler and, to a lesser degree, on the material strength of the coupler. The bar deformations, because of their original hot-rolled, hard mill surface, do experience any noticeable deformations, not even at ultimate load. Any improvement in the most unfavorable tolerance combination and engagement length, as have been used in the qualifications tests, will result in a more defined yield point, such as can be seen in some of the test results.

In summary, the softening effect has no influence on obtaining the minimum specified ultimate load of the splice and stays within the limits set by ACI 349, even for the rigorous requirements for unstaggered splices.

e) The failure mode for each specimen is described in the test report sheets submited on June 17, 1980. The failure mode of a bar slip has been described in detail under 1c.

f) Table 1 indicates the number of tests performed on each bar size with couplers designed for a capacity of 100% of minimum ultimate strength and 125% of minimum yield strength of the bar (ASTM A615, Grade 60). The test results are categorized into five percentage ranges of the specified load based on design capacity. These statistics include only the results of tests performed in the United States. In the evaluation of these statistics, it should be noted that most of these tests were performed under the most unfavorable conditions for engagement length and dimensional tolerances.

Also included in the last page of Table 1 are test results for bars manufactured by a foreign vendor and the associated confidence ranges.

Q 2. We have found that information regarding the following parameters and their variability is required in evaluating the performance of the DYWIDAG system. Discuss the following items and supporting test data:

a) The effect on performance due to dimensional tolerances in the splice couplers, rebars, and nuts, including those in threading.

b) The effect on performance due to tolerances in the physical properties and the chemical composition of the material rebars, couplers, and nuts.

c) The effect on performance due to variations in the field conditions during installation, such as the alignment of rebars to be spliced, temperature and humidity.

d) The effect on performance due to low (or high) service temperature on materials of rebars, couplers and nuts. For the purpose of evaluation and testing, the low temperature may be taken to be -20°F and the high temperature, 150°F.

e) The effect on performance due to a split in the rebar.

<u>Response</u>

a) As stated before, qualification tests had been performed using the minimum allowed engagement length (tolerance for coupler engagement on the bar is ± 1/2 inch) and couplers reamed out beyond their maximum allowed inside diameter to artificially create the condition of a combination of the extreme allowed tolerances for bar and coupler. As described in the system presentation submitted June 17, 1980, couplers and bars are checked by gages for proper dimensions before installation. Undersized bars or oversized couplers are rejected. Tests on regular splices with full engagement and normal dimensional tolerances show an increased ultimate strength of the splice and the frequency of bar rupture as failure mode increases.

The dimensional tolerances and their influence are discussed in detail below:

1. DYWIDAG threadbar

   a. Diameter including rib deformations - This is the most important dimension, which is controlled by U-shaped Go No-Go gages. The allowed minimum diameter has been taken into account in the qualification tests by over reaming the inside diameter of the couplers and nuts.

   b. Core diameter for the deformed and flat side of the bar - The tolerances are defined in the tolerance drawing. Core diameters are checked on three samples per heat. As bars exceeding the maximum weight deviation of -6 percent defined by ASTM A615 are rejected, this dimension will not vary enough to influence the carrying capacity of the splice.

   c. Rib width and length - This is determined by the way the finishing rolls are cut and can change only slightly during the rolling due to wear. The rolling passes are checked before the start of the rolling and any wear in the pass can only increase the rib size and, consequently, the carrying capacity.

2. Couplers and nuts

   a. Inner diameter - This is the most important dimension and is checked during and after manufacturing by the use of Go No-Go gages.

   b. Outer diameter or hex size - These tolerances are of little importance as they only affect the cross sectional area and have not been found to be a significant factor. Tolerances for the outside diameter and hex size are given in ASTM A519 and have been considered in the design of the outside diameter.

   c. Thread configuration - The cutting tools or thread taps for nuts and couplers are of a predetermined size controlled by the tolerance drawings. As the thread taps go through the coupler or nut, they will cut the correct size thread. Any wear in the thread taps would result in a narrower thread groove improving the carrying capacity.

b) The physical properties of the threadbar, coupler, and nut material are important for proper splice performance. The chemical composition is important only insofar as it helps to give the steel the specified physical properties. Except for ASTM A615, there is no other specification for the chemical and physical properties of the DYWIDAG threadbar, Grade 60 ksi. Grade 1026 has been selected for the couplers and nuts in order to guarantee weldability and sufficient machinability.

Experience from all tests performed on DYWIDAG threadbar splices has shown that the rib deformations on the bar engaged in the coupler are still undamaged after the ultimate load has been reached, no matter if the physical properties of the bar have been on the low or high side. Consequently, the physical properties of the threadbar, as long as within ASTM A615 specifications, do not have an influence on the carrying capacity of the splice.

The physical properties for the nut and coupler material have been specified such that the yield strength of the material is reached at the minimum specified ultimate load of the bar. Two series of tests have been performed to evaluate the influence of the coupler material properties on the splice performance. For these tests, couplers designed with a carrying capacity of 125 percent of the yield strength of the corresponding threadbar were selected to eliminate bar break as a failure mode.

The comparative tests were performed using identical minimum allowed engagement lengths of the bar in the coupler with the critical dimensions on the bar and coupler almost identical. The following are the test results:

Test Number	81891	81892	81893	82163	82164	82165
Bar size		No. 8			No. 8	
Coupler od		1 1/2			1 1/2	
Engagement length (inches)		1 1/2			1 1/2	
Coupler yield (psi)		75200			92600	
Coupler ult. strength (psi)		92700			111400	
Carrying capacity (kip)	76.0	76.0	75.8	75.0	73.6	77.0
Failure mode		Rupture of coupler			Stripping of coupler threads	

From this it can be concluded that the material properties of the hardware can affect only the failure mode but not the carrying capacity of the splice.

c) Critical for a proper performance of a DYWIDAG threadbar splice are only the correct physical dimensions of bar and hardware as well as sufficient engagement length. Alignment is only important to the extent that physical engagement of the coupler on the bar has to be possible. No mater how difficult it may have been to engage the coupler sufficiently on the bar (control of sufficient engagement length is given by the painted marks on the bar), once the splice is completed correctly, the specified carrying capacity can be guaranteed. The fact that, in a situtation with an alignment problem, it had been possible to engage the coupler by hand (or even with the help of a chain wrench) assures also that the specified torque moment can be applied effectively to control slip, considering that the torque moment will be at least 10 times the one applied for engaging the coupler on the bar.

Temperature has no effect on the installation and performance of the threadbar splice, neither has humidity. If required, threadbars may be spliced under water.

d) It is a known fact that in a temperature range of -20^{o}F to +150^{o}F, steel does not change its properties except for slight variations in relaxation. This by itself, is negligible due to the low permanent stresses in the reinforcing steel. Only at temperatures of 570^{o}F to 750^{o}F does the yield and ultimate strength of steel start to decrease. Couplers have been tested satisfactorily at a temperature of -290^{o}F using high strength DYWIDAG threadbars. At such low temperatures, the strength of steel increases while its ductility decreases.

The DYWIDAG threadbars are rolled in accordance with ASTM A615 and therefore behave with change of temperature just like any other brand of reinforcing bar. Couplers and nuts are made from cold-drawn, seamless, mechanical tubing according to ASTM A519, which is the same material used by most other reinforcing bar splice systems.

e) Dyckerhoff and Widmann have never had experience with split reinforcing bars. Further, an inquiry at the mill confirmed that due to the continuous cast billets, this phenomenon has never been encountered. Occasionally, a 1-inch deep split can be noted which results from the shear shock when hot shearing reinforcing bars to length. Hot shearing causes the threadbar ends to deform slightly, prohibiting their engagement in the coupler. For this reason, threadbars are always resheared or saw cut which would eliminate such split ends.

Even in case a split remained in the bar, it would not affect the carrying capacity of the splice. Due to the 450^{o} inclination of the flange of the thread deformations, the load transfer from bar to coupler or nut creates a compression force in the threadbar vertical to its axis, thus compressing the split. Tests have also been performed on special section threadbar tendons consisting of two bars with a half moon shaped cross section. The bars were tied together with wire and anchored by a simple nut gripping both bars. Although no quantitative test results are available, the tests were successful and duplicate the extreme condition of a reinforcing bar split longitudinally over its entire length.

Q 3. According the information given with your letter, dated June 17, 1980, the DYWIDAG system has been used in the construction of nuclear power plants in several foreign countries. We require the following information in order to evaluate the actual performance record of the system.

a) Provide details as to the actual locations at which splice bars are used in the above cited plants; the types of loads and stress levels these bars are subjected to and their erection specifications; any observed failure of these splices and their causes. Also indicate any deterioration due to corrosion or environmental effects, such as temperature and moisture.

b) Provide construction and installation records, such as amounts of discards, continuing performance test results and staggered or unstaggered splices. Also, provide the QA/QC procedures observed during erection.

c) The DYWIDAG system is presently used in Germany on Class 1 nuclear structures. Discuss how this system meets the German standard or criteria for splicing. How does the German standard compare to the American standard?

d) Discuss the technical merits and advantages for using this system versus other approved methods.

Response

a) DYWIDAG threadbar splices have been used in the foundation, bottom slab, the wall around openings, and in the roof dome in nuclear containment buildings and other Category I structures. The German Building Authority considers the Grade 60 threadbars to be equal to conventional reinforcing bars, and they have certified the use of this splice and end anchorages for unrestricted use in all types of structures. Consequently, the allowed stress levels in threadbars are the same as for other reinforcing bars. Germany allows a working stress in the reinforcing bar of 35 ksi. The yield strength of the rebar is used for the ultimate load design.

The erection specifications for the threadbar splice in Europe are simple. They consist of less than one page and specify:

1. After cutting, the threadbars have to be deburred to an extent necessary to allow engagement in the coupler. For contact splices, a saw cut is required with a maximum deviation of 2 degrees from square.

2. A suitable, durable marking has to be applied to the bars to control centering of the coupler.

3. One of the two bars has to be movable in longitudinal direction (the thread pitch has to be lined up during splicing).

4. The bar ends have to be free of flaking rust.

5. Torque wrenches or tools have to be calibrated.

6. Splices and end anchorages have to be assembled by qualified personnel.

7. Accurate reading of the achieved torque moment has to be possible. Alternatively, the torque may be set such that it switches off automatically when the required torque has been reached. Torque tools and wrenches have to be recalibrated at least in intervals of one half year.

The installation instructions to be used in the United States are given in the system presentation submitted on June 17, 1980 and provide much more detail.

To the best of our knowledge, no failures have been observed in the United States or any foreign country during tests on jobsites.

As noted in the response to Question 2.c, humidity and temperature have no influence on the splice performance. Corrosion can affect threadbars and splices the same way as it does conventional reinforcing bars. Flaking rust should be removed from the bar ends before splicing.

b) No construction and installation records are available on staggered or unstaggered threadbar splices. No continuing performance tests (production splice tests) are conducted on the jobsite. An inspector checks at random that the bar ends are properly engaged in the coupler and that the torque moment corresponds to the amount specified. QA/QC authorities do not require any more controls on threadbar splices on nuclear or other construction sites in Germany, because the Certificate of Approval for the DYWIDAG threadbar system does not require it.

A Certificate of Approval is required for all special construction material. It is issued by the German official Building Authority, the Institute for Construction Technics in Berlin, and gives specifications for the use of the material (see also response to Question 3.c). A Certificate of Approval has been issued for the Grade 60 as well as for the high strength DYWIDAG threadbar reinforcing steel and corresponding splices and end anchorages. It contains the following:

1. A general description of the materials used

2. Information that specifies that the steel has to comply with DIN 488 (similar to ASTM A615), Parts 1, 3, and 5; DIN 1045; Concrete and Reinforced Concrete; and the Guidelines for the Design of Reinforced Concrete Structures in Nuclear Power Plants for Extraordinary External Loads (see response to Question 3.c).

3. Load capacity and dimensions of couplers and nuts (see response to Question 3.c).

4. Quality Control

   a. Controls by the manufacturer - Mill Certificates on the materials are required. On five pieces per heat or batch of hardware, hardness tests have to be performed. Dimensions have to be checked with Go No-Go gages. On 5 percent of the hardware, the outside dimensions have to be checked, and on 1 out of 1,000 pieces a tensile test has to be performed.

   b. Controls by independent testing labs - Supervise the quality control under 4.a and check on the results by repeating measurements and hardness tests.

5. The specifications for the design using the threadbar system allow unlimited application according to DIN 1045.

6. Installation instructions (see response to Question 3.a).

7. QA/QC procedures onsite - The inspector shall see that the installation instructions are observed and the couplers are centered and torqued correctly. The QA/QC personnel shall have the right to take samples for testing in case irregularities in the manufacturing of the materials are suspected.

In addition to the tests required under item 4 above, checks are made on the continuing performance by testing 1 splice out of 2,000 (production splice test).

Although for other splice systems continuing performance tests on the jobsite are specified, the Building Authority in Germany has come to the conclusion that this is not required for the threadbar system as no special splice expertise is needed.

c) The German Standard for reinforced concrete structures is DIN 1045, Concrete and Reinforced Concrete: Design and Construction. It applies equally to all types of reinforced concrete structures including nuclear power plants. Except for the seven-page Guidelines for the Design of Reinforced Concrete Structures in Nuclear Power Plants for Extraordinary External Loads (Earthquakes, external explosion and airplane crash), no other design criteria or specifications exist for nuclear structures. The guidelines refer to DIN 1045 in regards to reinforcing steel and do not treat the subject of splices at all.

DIN 1045 specifies for reinforcing bar splicing the following:

1. The reinforced steel bars have to conform to DIN 488. DIN 488 specifies the properties of reinforcing bars to a similar extent as ASTM A615. DIN 488 is written mainly for cold-stretched and torqued reinforcing bars. Reinforcing bars in the as-rolled condition as the DYWIDAG threadbars need a special certification by the German government-controlled construction authority, in this case, the Institute for Construction Technics in Berlin. Certificates of Approval have been issued by the Institute for the Grade 60 threadbars and their splices and end anchorages for the use in all types of structures. This includes nuclear power plants. A Certificate of Approval also has been issued to use a cold-stretched, high strength threadbar reinforcing steel (yield 156 ksi and ultimate strength 192 ksi) with splices and end anchorages on nuclear power plants.

2. The load capacity for a splice must be at least 1.2 times the specified minimum ultimate strength of the reinforcing bar. The highest strength and most common reinforcing steel specified and used in Germany is a BSt 420/500 which is a steel cold deformed (stretched and torqued) to reach a yield strength of 61 ksi and an ultimate strength of 72 ksi. The DYWIDAG threadbar in Germany, like the threadbar in the United States according to ASTM A615, is not cold deformed. Therefore, in order to reach a yield of 61 ksi, it has to have a natural ultimate strength of about 90 ksi. The intent of DIN 1045 was to specify that a reinforcing bar splice hold the actual minimum ultimate strength of the bar. One and two tenths times 72 ksi is 87 ksi which corresponds roughly to the actual ultimate strength of noncold deformed bars.

3. The total slip under service load may not exceed 0.1 mm. The maximum stress allowed in reinforcing bars under service load is yield divided by 1.75, or 35 ksi.

   The DYWIDAG threadbar splice can comply fully with these requirements.

   DIN 1045 further allows that the entire reinforcement of a structure can be spliced in one section by either welding or threaded splices. Consequently, there are no restrictions in using unstaggered threadbar splices in regular or in nuclear structures.

d) The advantages and technical merits of using the DYWIDAG threadbar splice system are as follows:

   1. Depending on the number of splices per ton of steel, there are cost savings in materials.

   2. The time needed to perform a splicing operation is greatly reduced compared to other methods.

   3. The DYWIDAG splice can be installed in two steps as construction requirements warrant. This means a coupler and a lock nut can be installed and torqued on one bar end only, and the assembly placed such that the open coupler (with a seal to prevent the entry of concrete) butts against the form. After removal of the form and seal, the continuing bar with a lock nut can be connected and torqued. In this way, penetration of the form work by reinforcing bars can be avoided. This is important for a simple slip forming operation, for speedy removal, and preservation of the formwork.

   4. The crane time and, if critical path in the construction schedule, construction time can be reduced greatly.

   5. There is no fire hazard and other trades are not blocked from working in the area underneath or nearby the splicing operation.

   6. No weather restrictions apply to the splicing operation.

   7. No special operator expertise is required.

   8. No special cleanliness and storage requirements apply.

   9. Quality control of the splice is simple due to the few field variables.

   10. Very small slip under load.

   11. Excellent fatigue behavior of the splice

   12. End anchorages by nut and anchor plate are possible, eliminating the requirements of hooks.

Q 4. Discuss the planned uses of the DYWIDAG system on Nine Mile Point - Unit 2. Indicate the expected stress levels, the types of loads, and the configuration (staggered and unstaggered). Compare these uses with previous uses in foreign plants.

Response

DYWIDAG threadbar system will be used wherever possible in Category I structures to eliminate the need for rebar dowels protruding through wooden or metal forms. It is planned that this splice system will be utilized at the junction of (1) reactor building exterior wall and floor slabs at various elevations, (2) reactor building exterior wall and interior walls, and (3) around temporary openings.

In addition, this splice system will be utilized in other Category I structures such as the diesel generator building, the screenwell building, the radwaste building, etc., to avoid the use of insert panels for rebar dowel projections. Protruding dowels present a safety hazard and an obstacle to construction activities in the immediate area.

The expected stress level in each case will be well within the allowable stress as specified in applicable codes and standards. All load combinations for operating and design conditions will be in accordance with Nine Mile Point Unit 2 PSAR requirements. The types of loads will include dead, live, seismic, equipment, temperature, tornado, etc.

All splices will be unstaggered for this system. The use of unstaggered rebar splicing is a main advantage of using the DYWIDAG system.

Q 5. Tests were performed by Ontario Hydro comparing the DYWIDAG system with three other splice systems. If available, provide the results of these tests.

Response

Tests were performed by Ontario Hydro on at least four difference reinforcing bar splice systems. However, the test results are not available. It is known that all the test results on the DYWIDAG threadbar splice system met the requirements of the CSA Standard N287, Concrete Containment Structures for CANDU Nuclear Power Plants. Basically, the splice is required to carry the minimum specified ultimate load of the bar, and for unstaggered splices, similar slip limitations exist as in DIN 1045. Accordingly, the threadbar system is approved in Canada for use in unstaggered splices.

Q 6. The staff is aware of the use of this system by two nuclear plants in the United States, ANO-1 and Millstone, neither of which involved safety structures. Are you aware of the specific applications? If so, provide a description of its use and any available performance history on these plants.

Response

The DYWIDAG threadbar system has been applied in a number of nuclear power plants in nonsafety-related structures. A summary is enclosed in Table 2. In addition to this, 130 tons of Nos. 10 and 11 DYWIDAG threadbars, Grade 60 ksi have been installed in Categry I structures at Ontario Hydro's Bruce Reactor, and 450 tons of the same bars in Category I structures at their Pickering reactor containment structure.

In total, about 100,000 tons of DYWIDAG threadbars, Grade 60 ksi and more than 1 million splices have been installed successfully in all types of structures around the world.

We are not familiar with the use of DYWIDAG threadbar system at ANO-1. The application we are familiar with is for Northeast Utilities Millstone plant. Currently, the Millstone Unit 3 NPS in Waterford, Connecticut has an application for No. 18, Grade 60 DYWIDAG threadbars as rock anchors. Although this use is for a safety related structure, the function of the bar is likened to a conventional reinforcing bar used as a rock anchor. Some of the anchors do contain splices. However, they do not impact anchor performance. The onsite rock anchor test program was conducted for varying lengths of anchors both with and without intermediate splices. The influence of the splices or their locations was not apparent and the test anchors acted as if they were continuous reinforcing bar dowels. In this sense the DYWIDAG threadbar at Millstone are a different application from that contemplated at Nine Mile Point Unit 2, where they are to be used for mechanically splicing rebar for use in reinforced concrete structures.

Q 7. In conjunction with Code Case N-18G, provide QA/QC-related information such as training of splicers, qualification of splicers, and inspection of the rebar, coupler, and the finished splice.

Response

Training and qualification of splicers will consist of how to correctly apply the markings for the proper engagement lengths, information on the torque required for each bar size, and handling of the torque wrench or hydraulic torque tool. The instructions for these operations are given in Appendix 4, Installation Procedure for the DYWIDAG Threadbar Reinforcing System; and Appendix 5, Operating Instructions for the DYWIDAG Hydraulic Torque Tool, as submitted on June 17, 1980, with the system presentation. The splicer will prepare two qualification splices on the largest bar diameter (according to the new addendum to ACI Code 349, Splicing of Reinforcing Bars). The splices have to be tested and must meet the code case requirements.

The inspection of the rebar, coupler, and finished splice is covered in Appendix 4, Installation Instructions of the June 17, 1980 submittal.

TABLE 1

Statistics of Splice Test Results
DYWIDAG Threadbar, Grade 60 Ksi
Splice Design Capacity: 100 Percent of Ultimate Strength (90 Ksi)

Tests performed in the United States

Bar Size No.	Required Load	Number of Tests That Reached Precentage of Required Load 95%	95-100%	100-105%	105-110%	110% of U.L.
6	39.6 k	0	0	6	5	0
7	54.0 k	0	0	6	13	8
8	71.1 k	0	1	2	4	18
9	90.0 k	0	0	6	16	1
10	114.3 k	0	1	8	8	1
11	140.4 k	1[b]	3[a]	1	8	17
14	202.5 k	0	1	1	7	6
18	306 k	0	0	9	9	5
Total		1	6	39	70	56

Notes:

a. The inside diameter of the coupler had been reamed out beyond the allowed tolerances.

b. Error in engagement length.

TABLE 1
Continued

Statistics of Splice Test Results
DYWIDAG Threadbar, Grade 60 Ksi
Splice Design Capacity: 125 Percent of Yield (75 Ksi)

Tests performed in the United States

Bar Size No.	Required Load	Number of Tests That Reached Precentage of Required Load 95%	95-100%	100-105%	105-110%	110% of U.L.
6	33.0 k	3[a]	0	0	0	6
7	45.0 k	0	0	0	0	7
8	59.75k	1[a]	0	0	0	4
9	75.0 k	0	0	3	0	0
10	95.25k	1[a]	1[a]	1	0	9
11	117.0 k	0	0	1	0	8
Total		5	1	5	0	34

Notes:

a. The inside diameter of the coupler had been reamed out beyond the allowed tolerances.

TABLE 1
Continued

Statistics of Splice Test Results
DYWIDAG Threadbar, Grade 60 Ksi

Tests performed in the United States(1)

Bar Size	Required Load	Number of Tests That Reached Precentage of Required Load 95%	95-100%	100-105%	105-110%	110% of U.L.
22 mm	54.7 k(2)	0	2	2	9	10
26 mm	70.5 k(2)	0	0	30	5	46
28 mm	81.5 k(2)	0	0	1	0	17
36 mm	135 k(2)	0	0	0	0	2
40 mm	166 k(2)	0	0	0	0	15
50 mm	260 k(2)	0	2	0	0	3
No. 11	140.4 k(3)	0	0	0	0	2
No. 14	202.5 k(3)	0	0	2	3	0
No. 18	306 k(3)	0	0	0	0	3
Total		0	4	35	17	98

(1) Reinforced Bars supplied by a German vendor.
(2) Splice design capacity - 1.2 times the German specified ultimate strength (87 ksi) refer to response to Question 3.c.
(3) Splice design capacity - 100% of the American specified ultimate strength (90 ksi) refer to response to Question 3.c.

TABLE 2

List of Projects

Utilizing DYWIDAG Threadbars in Nuclear Nonsafety Related Structures

Owner	Engineer	Material	Location
Arkansas Power & Light	Bechtel Power Corp.	Grade 150 Threadbars	London, Arkansas
Consumers Power Company	Bechtel Power Corp.	Grade 60 Reinforcing Threadbars	Midland, Michigan
North East Utilities Services Company	Morrison-Knudsen Company, Inc.	Grade 150 Threadbars Rock Anchors	Millstone Nuclear Power Station Waterford, Connecticut
Texas Utility Services	Brown & Root, Inc.	Grade 60 Threadbars Rock Bolts	Comanche Peak Nuclear Power Station Glen Rose, Texas
Southern California Edison	Southern California Edison	Grade 60 Reinforcing Threadbars	San Onofre Nuclear Power Plant, California
Virginia Electric Power Company	Stone & Webster	No. 11, Grade 60 Reinforcing Threadbars	North Anna Power Station Mineral, Virginia
Niagara Mohawk Power Corporation	Stone & Webster	No. 8, Grade 60 Reinforcing Threadbars	Nine Mile Point Station Lycoming, New York

TABLE 3

DYWIDAG Threadbar Splices in Nuclear Power Plants
Applications, Stress Levels, and Quantities

1. Busher I and II, Iran

   a. Turbine Building I and II
      Allowed Working Stress in reinforcing bars: 35000 psi
      Allowed Stress under OBE (Operating Basis Earthquake): of 0.10G 43500 psi
      12000 splices for 50 mm (2") dia. Threadbars in the foundation slab
      1000 splices for 28 mm (1-1/8") dia. threadbars in the foundation slab and column connections

   b. Auxiliary Bay Building I and II (ABB)
      Working Stress: 35000 psi
      OBE of 0.25G: 43500 psi
      DBE (Design Basis Earthquake) of 0.50G : 61000 psi
      61800 splices for 28 mm (1-1/8") dia. Threadbars
      60 percent in the foundation and 40 percent in walls and roof for earthquake design.

   c. Screen Well Building I and II
      Loads and Stresses as in b.
      2800 splices for 50 mm (2") dia. Threadbars
      6200 splices for 28 mm (1-1/8") dia. Threadbars in floors and walls.

   d. Reactor Building I and II
      Loads and Stresses as in b., in addition: Stress under internal abnormal loading: 61000 psi
      36000 splices for 28 mm (1-1/8") dia. Threadbars for concentration of reinforcement and connections for all areas (walls, roof, and columns)

   e. Auxiliary Buildings
      Loads and stresses as in a.
      24000 splices for 28 mm (1-1/8") dia. Threadbars mainly in highly reinforced columns and column connections

   f. Ventilation Stack
      Loads and Stresses as in b.
      7000 splices for 28 mm (1-1/8") dia. Threadbars for vertical reinforcement

2. Unterweser, Germany
   Reactor Building

Working Stress:	35000 psi
DBE of 0.05G:	55000 psi for static loads
	61000 psi for dynamic loads

3. Grafenrheinfeld, Germany
   Reactor Building
   Working Stress: 35000 psi
   DBE of 0.1 G: 61000 psi
   OBE of 0.05G: 43500 psi
   Internal abnormal loading: 61000 psi
   4000 splices for 28 mm (1-1/8") dia. Threadbars
   450 splices for 22 mm (7/8") dia. Threadbars for concentration of reinforcement and connections for all areas (walls, roof, and columns)

4. Grohnde
   Reactor Building
   Working Stress: 35000 psi
   DBE of 0.05G: 61000 psi
   Internal abnormal loading: 61000 psi
   About 7000 splices for 28 mm (1-1/8") and 22 mm (7/8") Threadbars for concentration of reinforcement and connections for all areas (walls, roofs, and columns)

5. Phillipsburg, II, Germany
   Reactor Building
   Working Stress: 35000 psi
   DBE of 0.21G: 61000 psi
   OBE of 0.13G: 43500 psi
   Internal abnormal loading: 61000 psi
   About 6000 splices for 28 mm (1-1/8") and 22 mm (7/8") dia. Threadbars for concentration of reinforcement and connections for all areas (walls, roofs, and columns)

6. Trillo, Spain
   Reactor Building
   To date, 20000 splices for 40 mm (1-5/8") dia. Threadbars in the foundation slab and interior structures.
   Stress levels unknown

7. Doel, Belgium
   Reactor Building
   To date, 25000 splices for 40 mm (1-5/8") dia. Threadbars mostly in interior walls (vertical and horizontal reinforcement)
   Stress levels unknown