General File

Duke Power Company

Power Building

422 South Church Street, Charlotte, N. C. 28242

William O. Parker, Jr.
Vice President
Steam Production

August 14, 1979

Telephone: Area 704
373-4083

79 AUG 17 A11 : 29

Mr. James P. O'Reilly, Director
U. S. Nuclear Regulatory Commission
Region II
101 Marietta Street, Suite 3100
Atlanta, Georgia 30303

Re: RII:JPO
50-269
50-270
50-287

Dear Mr. O'Reilly:

My letter of July 6, 1979 provided an initial response to IE Bulletin 79-02 and Revision 1 to IE Bulletin 79-02. In this regard, please find attached a revised response which includes information previously submitted as well as supplemental information, including an update of the inspection results.

Also attached is a copy of Teledyne Engineering Services Technical Report—TR-3501-1 which is referred to in the attached response.

Very truly yours,

William O. Parker, Jr.

William O. Parker, Jr. By

RLG:scs
Attachment

cc: U. S. Nuclear Regulatory Commission
Office of Inspection and Enforcement
Washington, D. C. 20555

(w/o Teledyne Engineering Service
Technical Report TR-3501-1)

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A02

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OCONEE NUCLEAR STATION

Responses to USNRC Bulletin 79-02, Revision 1

Original: July 6, 1979

Revision 1: August 14, 1979

Oconee Nuclear Station is a three (3) unit operating station located near Seneca, South Carolina. The following is a summary, by item, of the extent and manner in which Duke Power Company intends to satisfy Actions 1 through 4 of IE Bulletin 79-02, Revision 1.

Response 1: Duke Power Company is accounting for base plate flexibility in the calculation of expansion anchor bolt loads for all Nuclear Safety Related/seismic pipe support base plates using a conservative hand calculation method which has been verified by non-linear finite element analysis. The models and boundary conditions, including appropriate load displacement characteristics of the anchors used for the finite element analyses, are based on Duke studies and on work performed by Teledyne Engineering Services which was sponsored by a group of thirteen (13) utilities formed to respond to generic items of IE Bulletin 79-02. A complete description of the finite element model is submitted in the Teledyne Engineering Services report attached (Attachment #1). A description of the hand calculation methods is also attached (Attachment #2).

All re-analysis is complete for Nuclear Safety Related/seismic support base plates located in Unit #3 Containment, Auxiliary Building, and Turbine Building with the exception of 103 supports in the Auxiliary Building which are still being analyzed. These remaining supports are all field typical supports for which Duke Power Company had not retained design drawings. These supports were identified during the surveillance program. All re-analysis work will be completed for all Unit 3 supports in areas that will be inaccessible during operation, prior to startup of Unit 3. The re-analysis of Unit 2 Containment is complete and the re-analysis of Unit 2 Auxiliary Building is 3 percent complete. The re-analysis of Unit 2 Turbine Building has not started. The re-analysis of the Unit 1 Containment is 55 percent complete and the re-analysis of Unit 1 Auxiliary Building is 68 percent complete. The re-analysis of Unit 1 Turbine Building is 70 percent complete. Schedule for completion of remaining re-analysis work is October 1, 1979. In some cases, conservatively including the effect of plate flexibility has reduced the expansion anchor factor of safety below that outlined in Response 2. Any that have a factor of safety less than two are given immediate attention and determination of system operability is immediately begun in parallel with a rigorous (finite element model) analysis of the expansion anchor factor of safety.

Response 2: Self-drilled type, wedge type, and sleeve type expansion anchors have been used in Nuclear Safety Related/seismic pipe support applications at Oconee Nuclear Station. The majority of expansion anchors are of the self-drilled type. Duke Power Company is presently verifying that the minimum factor of safety between expansion anchor design load and anchor ultimate capacity determined from static load tests, is five (5) for shell type expansion anchors and four (4) for wedge and sleeve type expansion anchors. This process of verification is outlined in Response 1.

Oconee Nuclear Safety Related/seismic pipe support expansion anchor installations are restricted to normal weight structural concrete of varying nominal strengths. Expansion anchor bolt ultimate load capacities are based on manufacturer's test results and recommendations for normal weight concrete and installed concrete strengths. None are installed in concrete block masonry.

The effects of shear-tension interaction, minimum edge distance and bolt spacing on expansion anchor ultimate capacity is properly accounted for in computing the expansion anchor factors of safety.

Response 3: Duke Power Company designs pipe supports to resist all applicable loadings including seismic loads, hydro test loads, normal operating loads, thermal loads, etc. Each support is designed for a static or quasi-static load resulting from the most critical combination of applicable loadings. Duke Power Company co-sponsored tests performed by Teledyne Engineering Services to demonstrate that expansion anchors installed at Oconee Nuclear Station will perform adequately under both low cycle/high amplitude loading (seismic) and high cycle/low amplitude loading (operating). The report on cyclic testing of concrete expansion anchors by Teledyne Engineering Services is provided in Attachment #1.

Response 4: Existing QC documentation for expansion anchor installations at Oconee is not sufficient to provide written verification that each expansion anchor meets the requirements of Action 4(a) and 4(b) of IE Bulletin 79-02. Duke Power Company has initiated a test program, as required by IE Bulletin 79-02 to verify that applicable design requirements have been met. Oconee Unit 3 was down for refueling during the reporting interval of this Bulletin and therefore the pipe supports within Containment and high operating radiation areas of the Auxiliary Building were selected for initial inspection and testing because of future inaccessibility. Testing and inspection on all supports for Nuclear Safety Related/seismic piping systems is complete with the exception of 25 supports in containment, 77 supports in the Auxiliary Building and 22 supports in the Turbine Building. This testing and inspection is currently under way. The majority of the untested supports are those that were initially identified as having sleeve or wedge anchors. All inspection and testing of Unit 3 expansion anchors which will be inaccessible during operation will be completed prior to Unit 3 startup.

Inspection and testing of expansion anchors in the accessible areas of Units 1 and 2 Auxiliary Buildings will be a continuing effort supplemented by inspection and testing of inaccessible areas of each unit when it is down for refueling.

The verification program consists of two (2) phases. Phase 1 is a field surveillance program to identify each Nuclear Safety Related/seismic pipe support which was installed using expansion anchors and compare its "as built" configuration, location, and expansion anchor size and type to existing documents. Phase 2 is a field inspection and testing program to verify that specified design size and type is correctly installed. The Phase 2 program for shell-type expansion anchors was developed and implemented on Unit 3 in accordance with the requirements of IE Bulletin 79-02, Revision 0. Full testing and a thread engagement check was required for one randomly selected shell-type anchor per plate on each pipe support hanger in addition to a general visual inspection. The anchors were pull tested at 25 percent of ultimate load which is 25 percent in excess of the maximum envelope design load. If the anchor failed pull test or thread engagement, then each anchor on the plate was tested or inspected for the parameter which failed. All bolts in shell type anchors were turned and retorqued to assure operability.

A total of 281 pipe supports were inspected inside Unit 3 Containment. 526 shell type anchors were pull tested or visually inspected with bolts removed. 28 anchors were classified as having rejectable installation deficiencies. One anchor failed the pull test and the remaining deficiencies were identified visually. 158 of the 281 pipe supports are actually Nuclear Safety Related/seismic. 14 of these supports contained one or more expansion anchors which were classified as rejectable. The 14 supports were well distributed among the Nuclear Safety Related/seismic systems, i.e. there was no grouping preference for a single system. A total of 22 Nuclear Safety Related/seismic anchors were rejected for installation deficiencies, from a test and inspection sample of 323 anchors. This sample represents approximately 49 percent of the Nuclear Safety Related/seismic anchors in Unit 3 Containment. Further review of the 28 rejected anchors indicates that 16 had deficiencies which significantly reduced their ultimate load carrying capacity while 12 contained deficiencies of a lesser nature (see Attachment #3). Duke Power Company has additionally analyzed the 14 pipe supports with all deficient anchors assumed to be absent and concluded that existing design margins were adequate to assure operability of all Nuclear Safety Related/seismic piping systems in accordance with the plant design bases.

A total of 682 supports have been tested in the Unit 3 Auxiliary Building. 1085 shell type anchors have been pull tested and/or visually inspected. 141 anchors were classified as having rejectable installation deficiencies. 6 anchors failed

the pull test and the remaining deficiencies were identified visually. The 141 anchors were in a total of 83 supports. Further review of the 141 rejected anchors indicates that 29 had deficiencies which significantly reduced their ultimate load carrying capacity while 112 had deficiencies of a lesser nature (see Attachment #3). The 29 anchors were located in 18 supports.

A total of 16 supports have been tested in the Unit 3 Turbine Building. 43 shell type anchors have been pull tested and/or visually inspected. 13 anchors were classified as having rejectable installation deficiencies. No anchors failed the pull test and the remaining deficiencies were identified visually. The 13 anchors were in a total of three supports.

In response to numerous discussions with Region II inspectors, the testing crews were instructed to gather two additional pieces of information not addressed in Duke's test procedure. They were instructed to provide the dimension of any holes showing signs of oversizing and they were also instructed to measure shoulder to plug dimensions on all anchors which have their bolt removed during testing. All holes identified as being oversized are being repaired where required by analysis. The acceptable shoulder to plug dimension was the anchor length minus plug length + 1/8" or - 1/4". Any bolts exceeding the +1/8" tolerance but passing pull test were determined acceptable, but any bolt exceeding the -1/4" tolerance was rejected, even if it passed the pull test, due to possible insufficient shear cone capacity (see Attachment #3).

Any anchor that passes pull test and has minimum acceptable embedment depth is considered fully adequate even though it may fail to meet certain visual requirements deemed to be indications of proper installation. A pull test is an actual capability test assuring a minimum anchor capacity equal to the test load and has sufficient margin of safety due to the following reasons:

a. The test load (Pu/4) is 25 percent greater than the maximum envelope design load. The actual expansion anchor design loads were not available for each anchor prior to testing, therefore, each shell anchor design load was conservatively assumed to be equal to the full Pu/5 for purposes of the testing.

b. Calculation techniques to establish expansion anchor design loads contain inherent margins for the following reasons:

   1. Conservative specification of site seismic event.

   2. Conservative generation of "in structure" response spectrums.

   3. Conservative structural damping used.

   4. Seismic input spectra used for piping analysis is en-

veloped by elevation, then each support is simultaneously subjected to this input.

5. Inherent conservatism in response spectrum analysis technique when combining intermodel components without phase consideration.

6. Conservative piping damping used in dynamic analysis.

7. Conservative "hand calculation technique" used to include base plate flexibility.

8. Differential seismic building motions conservatively input to piping analysis.

c. There were just three anchors with deficient shoulder to plug dimensions which failed pull test out of a sample of 261 anchors.

d. Linear shear-tension interaction was used and is a very conservative relationship with which to establish anchor factor of safety. This is verified by the Teledyne Engineering Services report attached (Attachment #1).

e. It is conservative to assume that the anchors carry all the shear. All or some of the plate shear will be taken through concrete/plate friction without or with limited bolt engagement. The anchor allowable tensile load is unfairly reduced by assuming frictionless concrete/plate interface and theoretically relying on the anchor to carry the full shear.

The remaining pipe supports in Oconee balance of plant and inside Units 1 and 2 Containments are expected to exhibit a similar distribution and number of improperly installed expansion anchors. A limited number of these anchors would have a significantly reduced ultimate load carrying capability. The strength margins originally designed in these connections and bolt patterns provide considerable reserve in the event that an expansion anchor fails to carry its load and redistribution of this load is necessary to the adjacent anchors, as was shown for each of the 14 supports containing a deficient anchor in Unit 3 Containment. Duke therefore concludes that Nuclear Safety Related/seismic piping system operability is not jeopardized by the presence of a limited number of distributed expansion anchors which have been "improperly installed".

Duke is currently revising its shell type expansion anchor testing and inspection program for Units 1 and 2 to include revisions as required to comply with IE Bulletin 79-02, Revision 1, which was recently received. The sleeve and wedge

type expansion anchor testing and inspection program fully complies with IE Bulletin 79-02, Revision 1.

In order to address the question of relationship of cyclic/load carrying capacity to installation procedure (anchor preload), the tests referred to in Response 3, performed by Teledyne Engineering Services and sponsored by the group of thirteen (13) utilities, have been performed on anchors installed in accordance with manufacturer's recommended installation procedures and have no more preload than is provided by the use of these procedures. Based on Duke's understanding of the behavior of expansion anchors and on the cyclic testing which has been performed, Duke Power Company is confident that the anchors will perform adequately.

ATTACHMENT #2

MECHANICAL & NUCLEAR DIVISION

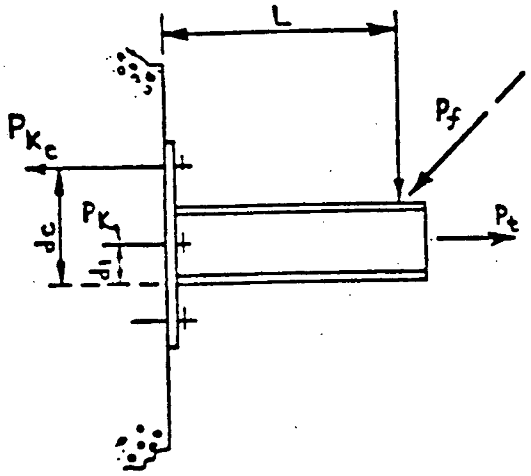
DESIGN SECTION, SUPPORT/RESTRAINT GROUP

BULLETIN 79-02 REVIEW FOR OCONEE NUCLEAR STATION

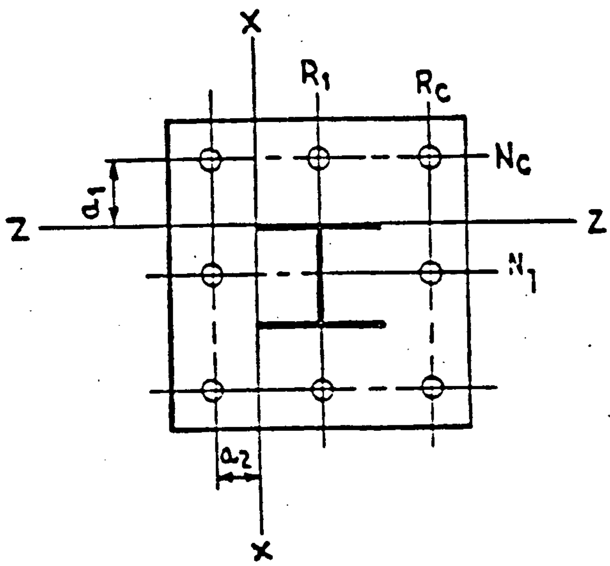
BASE PLATE AND ANCHOR BOLT ANALYSIS METHOD

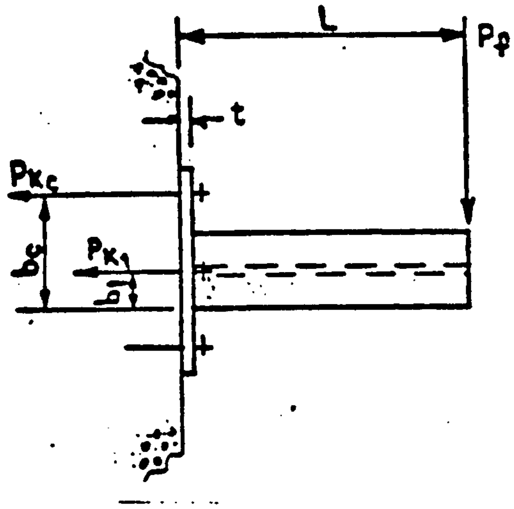
BASE PLATE AND ANCHOR BOLT ANALYSIS METHOD

1. Members welded to base plates can be symmetrical and non-symmetrical shapes.
2. Bolt patterns should be symmetrical about centroidal axis.
3. C/C spacing between anchors should not exceed maximum values shown on page 5.
4. Plates with self-drilling anchors should be checked for normal, upset, and faulted loading combinations.
5. For any bolt pattern not covered in this design procedure plate shall be stiffened adequately and flexibility factor may be taken as 1.0 for moments and 1.4 for tension (i.e. $\alpha = \gamma = 1.0$).
6. Design Procedure:



ELEVATION





PLAN

P_{k_1}, P_{k_c} represents pullout/bolt in the respective row.

N_1, N_c represents number of bolts in the respective row.

R_1, R_c represents number of bolts in the respective column.

P_{k_c} is the maximum critical pullout due to all loads; P, P_f, & P_t

F_t = allowable tension/bolt

f_t = applied tension/bolt = P_{k_c} *

F_v = allowable shear/bolt

f_v = applied shear/bolt

U_t = ultimate tension/bolt

U_v = ultimate shear/bolt

α = Flexibility factor moment axting about Z-axis

γ = Flexibility factor moment acting about X-axis

For flexibility factor see pages 3 thru 6

$$P_{k_c} = \frac{PL\,d_c \cdot \alpha}{N_1(d_1)^2 \ldots + N_c\,(d_c)^2} + \frac{P_t \cdot 1.4}{\text{total No of Bolts}} + \frac{P_f\,L\,b_c\,\gamma}{R_1(b_1)^2 \ldots + R_c(b_c)^2}$$

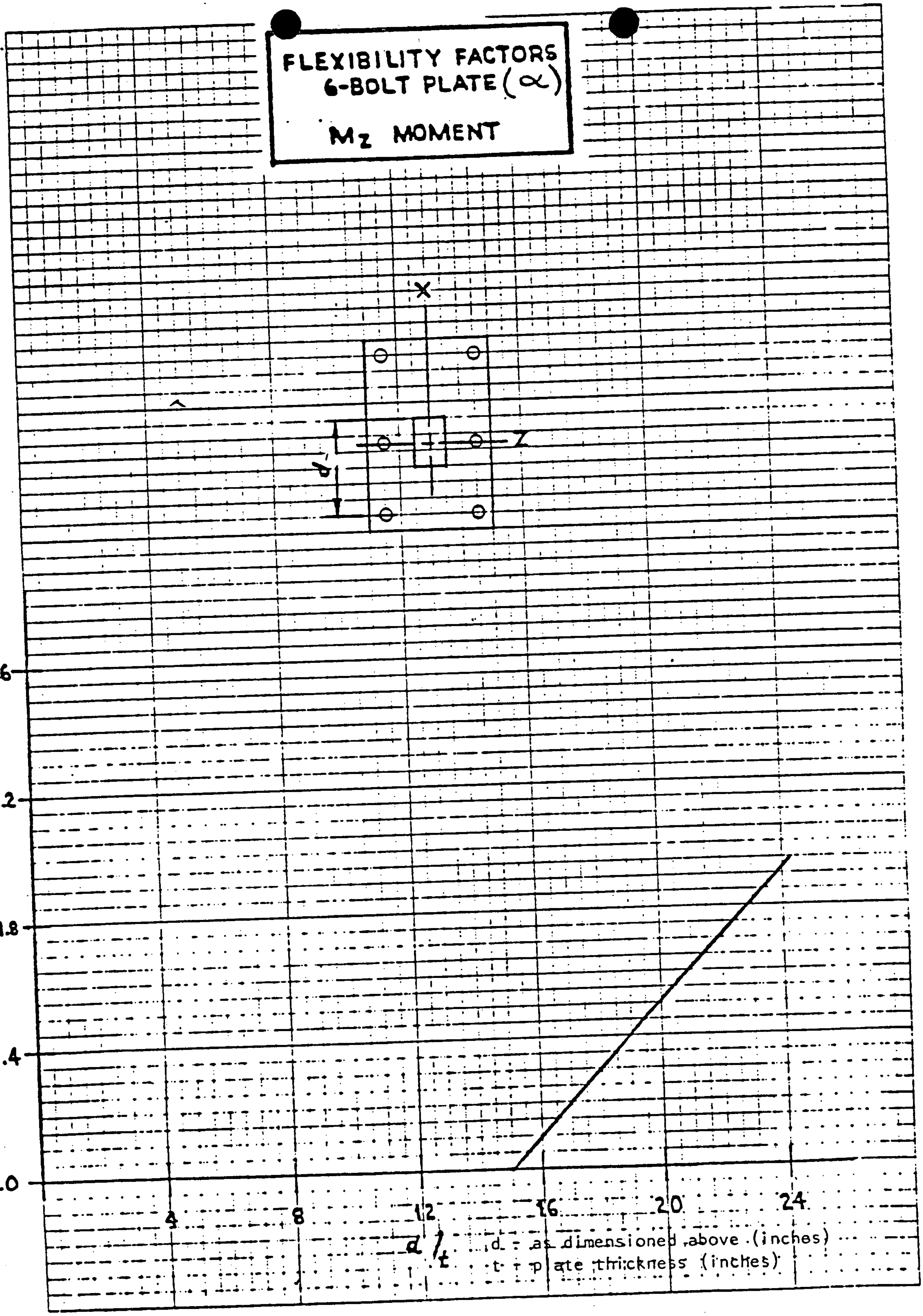
When determining f_v consider shear forces due to loads and torsional moments as contributing to shear applied to the anchor bolts.

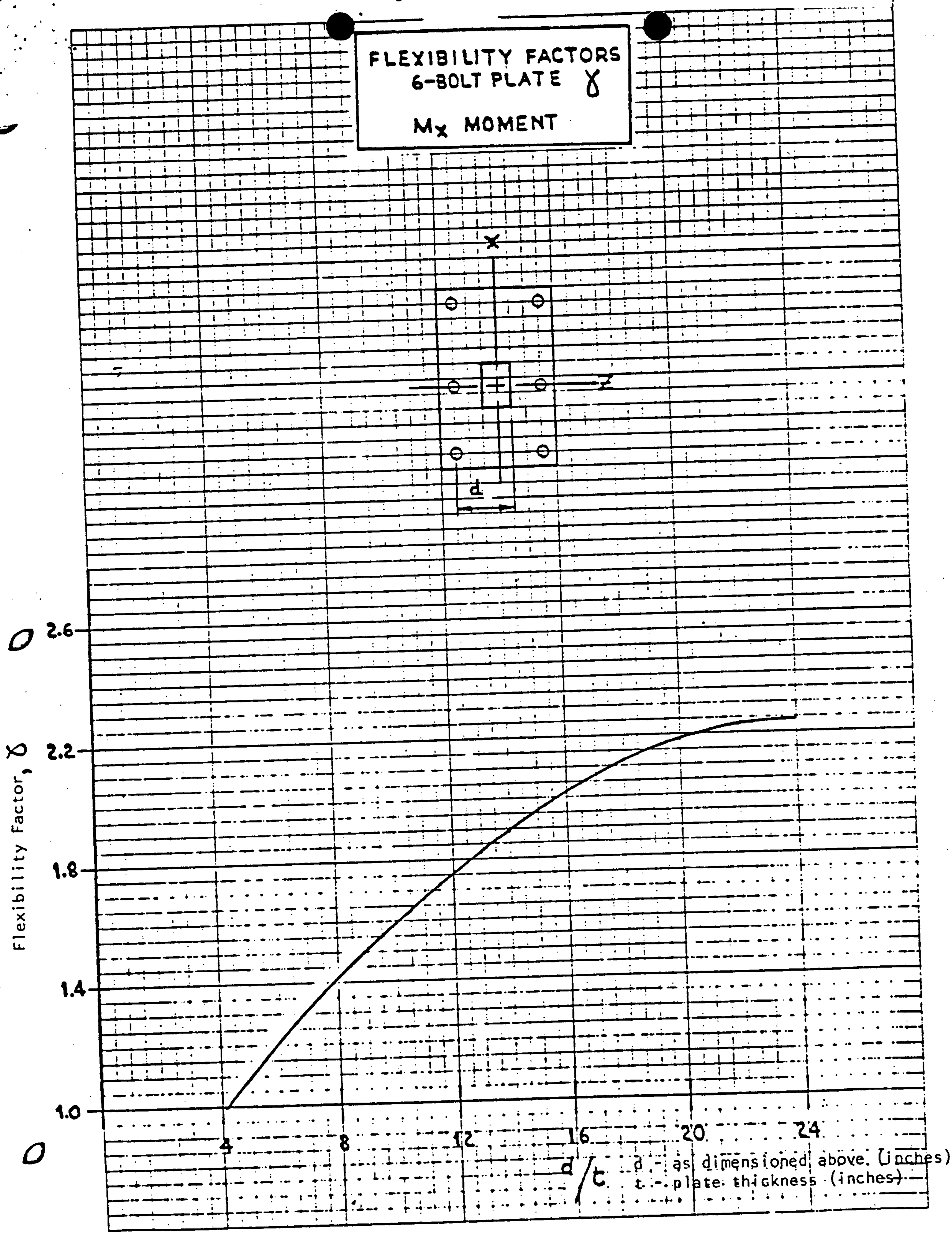
After f_t & f_v have been determined, check the bolt interaction:

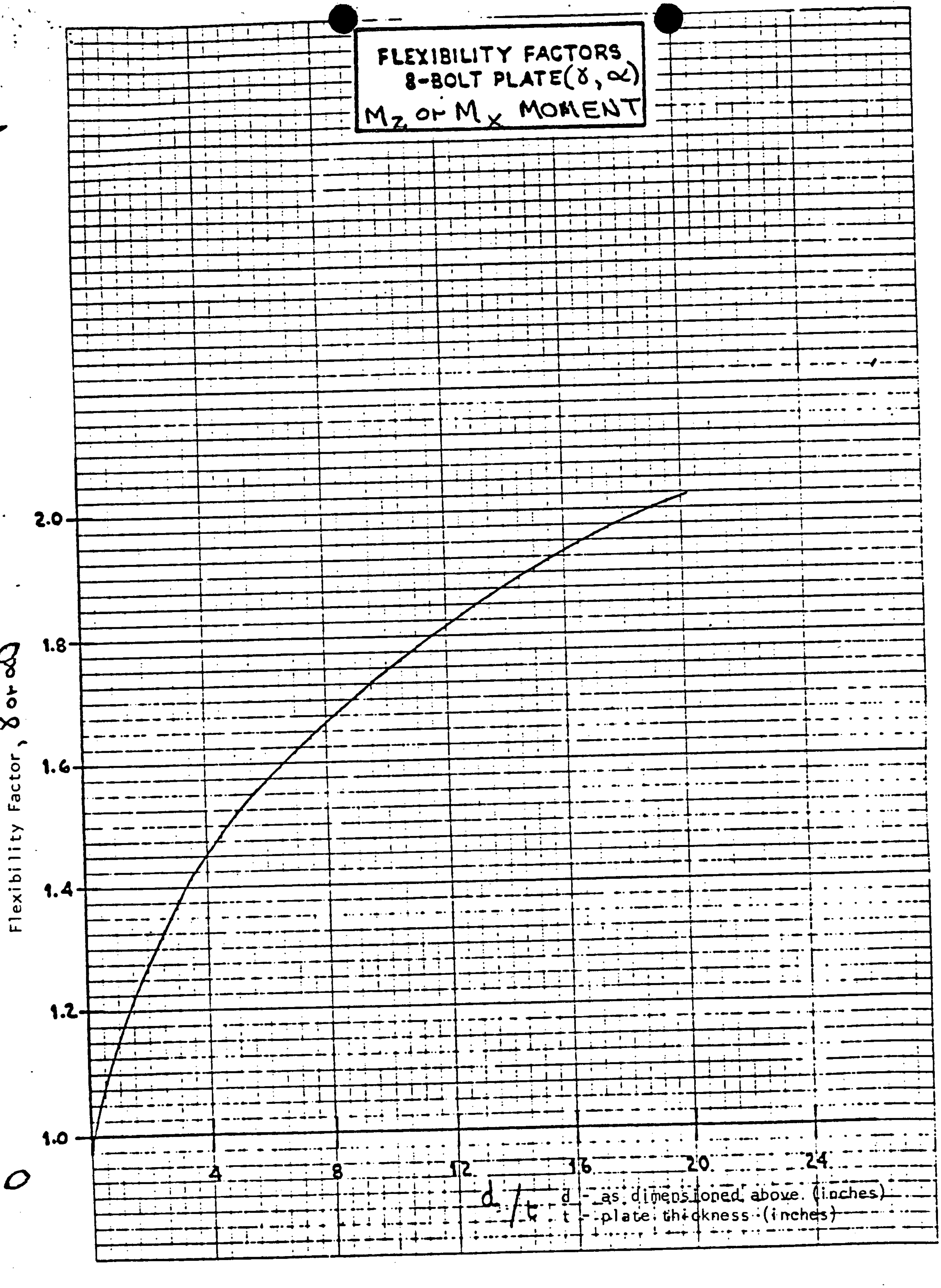
$$\frac{f_t}{F_t} + \frac{f_v}{F_v} \leq 1.0$$

* When selecting concrete anchor bolts use this value for basis of anchor size required.

FLEXIBILITY FACTORS	SYMM + NON-SYMM. SHAPES
2 Bolt Plates	1.25
4 Bolt Plates	1.0
6 Bolt Plates	See Pages 4 and 5
8 Bolt Plates	See Page 6
Two Column (Moment about Z Axis)	
4 Bolt	1.4
6 Bolt	1.4


FLEXIBILITY FACTORS
6-BOLT PLATE (α)
Mz MOMENT
X
Z
d
2.6
2.2
1.8
1.4
1.0
Flexibility Factor, γ
4
8
12
16
20
24
d/t
d = as dimensioned above (inches)
t = plate thickness (inches)


FLEXIBILITY FACTORS
6-BOLT PLATE γ
Mx MOMENT
x
z
d
2.6
2.2
1.8
1.4
1.0
Flexibility Factor, γ
4
8
12
16
20
24
d/t
d - as dimensioned above (inches)
t - plate thickness (inches)


FLEXIBILITY FACTORS
8-BOLT PLATE(γ, α)
Mz or Mx MOMENT
Flexibility Factor, γ or α
2.0
1.8
1.6
1.4
1.2
1.0
0
4
8
12
16
20
24
d/t
d - as dimensioned above (inches)
t - plate thickness (inches)

SUMMARY

REACTOR BUILDING (Deficiencies per 526 anchors tested and/or inspected.)

Significant

7 - Welded
5 - Loose Anchor
2 - Shell Broken
1 - Concrete Damaged
1 - Failed Pull Test
16

Other

3 - Not Perp.
3 - Damaged Threads
1 - Def. Shoulder to Plug
1 - Not Properly Installed
1 - Bolt Bent
3 - Shell not Flush
12

AUXILIARY BUILDING (Deficiencies per 1085 anchors tested and/or inspected.)

Significant

4 - Welded
10 - Loose Anchor
0 - Shell Broken
9 - Concrete Damaged
6 - Failed Pull Test
29

Other

54 - Not Perp.
8 - Damaged Threads
27 - Def. Shoulder to Plug
17 - Shell not Flush
5 - Anchor Cut Off
1 - Damaged during Test
112

TOTAL (Deficiencies per 1611 anchors tested and/or inspected.)

Significant

11 - Welded
15 - Loose Anchor
2 - Shell Broken
10 - Concrete Damaged
7 - Failed Pull Test

Other

57 - Not Perp.
11 - Damaged Threads
28 - Def. Shoulder to Plug
1 - Not Properly Installed
1 - Bolt Bent
20 - Shell Not Flush
5 - Anchor Cut Off
1 - Damaged During Test

AUXILIARY BUILDING

SYSTEM	SIGNIFICANT	OTHER
01A	0	0
03A	2 - Loose Anchor	4 - Def. Shoulder to Plug 1 - Not Perp.
14B	1 - Failed Pull Test	3 - Damaged Threads 9 - Shell not Flush 1 - Damaged during Test 8 - Def. Shoulder to Plug 4 - Not Perp.
20B	1 - Failed Pull Test	1 - Def. Shoulder to Plug 2 - Not Perp.
48	0	1 - Shell not Flush
51A	1 - Welded 2 - Loose Anchor 1 - Failed Pull Test	2 - Anchor Cut Off 3 - Damaged Threads 14 - Not Perp. 0 - Def. Shoulder to Plug 1 - Shell not Flush
51B	0	4 - Not Perp. 2 - Def. Shoulder to Plug
53B	2 - Welded 5 - Concrete Damaged 4 - Loose Anchor 3 - Failed Pull Test	19 - Not Perp. 5 - Shell not Flush 8 - Def. Shoulder to Plug 1 - Anchor Cut Off
54A	2 - Loose Anchor 4 - Concrete Damage	2 - Anchor Cut Off 1 - Def. Shoulder to Plug
55	0	0
56	1 - Welded	3 - Def. Shoulder to Plug 9 - Not Perp. 1 - Damaged Threads 1 - Shell Not Flush

AUXILIARY BUILDING, con't.

SYSTEM	SIGNIFICANT	OTHER
57	0	0
59	0	0
61	0	1 - Damaged Threads
63	0	1 - Not Perp. 0 - Def. Shoulder to Plug

REACTOR BUILDING

SYSTEM	SIGNIFICANT	OTHER
03	0	1 - Damaged Threads 2 - Not Perp.
14B	3 - Welded 1 - Loose Anchor 1 - Shell Broken 1 - Concrete Damaged	1 - Not Properly Installed 1 - Bolt Bent
50	1 - Shell Broken 1 - Loose Anchor	0
51A	2 - Welded	1 - Damaged Threads 1 - Shell not Flush
53A	1 - Loose Anchor 1 - Failed Pull Test	2 - Shell not Flush 1 - Damaged Threads
56	0	0
04	0	0
NNSR 48,55,57,63	2 - Welded 2 - Loose Anchor	1 - Not Perp. 1 - Def. Shoulder to Plug