GUIDE THIMBLE TUBE WEAR

IN WESTINGHOUSE FUEL ASSEMBLIES

MAY 1979

Dupe of 8005020316

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1.0 SUMMARY

The [ ] fuel assemblies guide thimble tubes is presented in Section 2 of this report. (a,c)

Based on [ ] observations a guide thimble wear model is developed in Section 3. The guide thimble wear model is used to predict wear in various fuel assembly designs. (a,c)

In Section 4, the fuel assembly structural integrity, with worn thimble tubes, is evaluated for normal operation, worst accident conditions and non-operational loads.

As a result of this evaluation it is concluded, in Section 5, that the guide thimble wear does not affect the structural integrity of the fuel assembly guide thimble tubes.

2.0 EVALUATION OF THE [ ] EXAMINATIONS (a,c)

2.1 SCOPE OF GUIDE THIMBLE TUBE EXAMINATION AT [ ] (a,c)

49 guide thimble tubes in 12 fuel assemblies were examined in the [spent fuel pit with an eddy current device.] (a,b,c)

[ ] (a,b)

Figure 1 shows the core location of the [ ] fuel assemblies that were examined. (b,c)

2.2 GUIDE THIMBLE TUBE EXAMINATION TECHNIQUE

Two types of [ ] were made to evaluate the eventual reduction of thimble tube thickness, namely: (c)

1. Qualitative measurements were performed on [ ] guide thimble tubes to determine the approximate axial distribution of areas of reduced thimble wall thickness. These measurements were used as a guide for selection of thimbles to be quantitatively examined. The qualitative measurements provide the average wear in a guide thimble tube cross section. (b,c)

2. Quantitative measurements were performed on [ ] guide thimble tubes out of [ ] to determine depth and orientation of the wear. The measurements were performed only on those thimbles exhibiting pronounced wear as indicated by the qualitative measurements. The quantitative measurements provide the local wear within a tube of section [ ] width. (b,c) (b,c) (b,c)

   Figure 2 shows the fuel assembly parts that were examined with the [ ] Figure 3 shows typical [ ] (a,c) (a,c)

2.3 EVALUATION OF [ ] GUIDE THIMBLE WEAR RESULTS (a,c)

Table 2.1 provides the average wear results for [ ] fuel assemblies. (a,c)

In Table 2.1, the wear results are classified according to 4 parameters:

[ ] (a,b,c)

[ ] (a,c)

[ ] (a,c)

[ ] (a,c)

The [ ] of wear are illustrated in Figure 3. (a,c)

The [ ] was reduced and statistically evaluated to identify possible sources of non-randomness of the wear results: (a,c)

1. [ ] (a,b,c)

2.

3.

4.

TABLE 2.1

WEAR (%) IN GUIDE THIMBLE TUBE: 4-WAY CLASSIFICATION
(ROUNDED NUMBERS)

(a,b,c)

(a, b, c)

3.0 THE GUIDE THIMBLE WEAR MODEL

3.1 GUIDE THIMBLE WEAR MECHANISM

The wear model assumes the following wear mechanism:

1. [redacted] (a,c)
2.
3.
4.
5.
6.
7.

The wear volume is calculated using the following equation:

[redacted] (a,c)

3.2 GUIDE THIMBLE WEAR PREDICTIONS FOR [14 X 14 AND 17 X 17] FUEL ASSEMBLIES (a,c)

Based on the wear mechanism described in Section 2.1, wear predictions are developed for [ ] fuel assemblies. These are the [ ] fuel arrays in Westinghouse fuel assemblies. A generic evaluation is performed for a typical [ ] fuel characteristics that affect the wear phenomenon are compared in Table 3.1. (a,c) (a,c)

Figure 5 provides the best estimate predicted wear depth, in [ ] in percent of wall thickness, as a function of weeks of continuous operation under a [ ] The wear is axially located below [ ] (a,c) (a,c) (a,c)

Figure 5 also compares the wear model predictions to [ ] All the measured results, except one, are below the predicted wear values. (a,c)

The best estimate wear predictions are used in the next section to calculate the stress intensities in the guide thimble tubes.

TABLE 3.1

COMPARISON OF [ ] FUEL ASSEMBLY AND CONTROL ROD CHARACTERISTICS (a,c)

(a,c)

[ ]

4.0 FUEL ASSEMBLY STRUCTURAL INTEGRITY WITH WORN THIMBLE TUBES

The design bases for evaluating the fuel assemblies structural integrity are those described in the Safety Analysis Report.

The analysis and the conclusions presented in this section are based on the following conservative assumptions:

[ ] (a,c)

1.

2.

3.

4.

5.

6.

4.1 NON-OPERATIONAL 6g LOADING

The non-operational loads are shipping and handling loads; they are assumed to be 6g although these loads are closely monitored during handling operations and kept well below 6g. The 6g limit is a conservative design basis.

The handling load is applied to the top nozzle and transmitted to the guide thimble tubes through the adapter plate (Figures 2 and 4). The deformation of the adapter plate induces an uneven distribution of the loads in the thimble tubes, the corner tubes carrying most of the handling load.

The maximum shear theory is used to calculate the allowable stress at beginning of life when the guide thimble tube material is ductile. The normal stress in the corner tubes carrying the maximum load is plotted as a function of time for [ ] (a,c) fuel assemblies in Figure 6. These stresses are compared to the minimum S_y at 140°F handling temperature in Table 4.1.

At end-of-life, for the handling temperature, the guide tube material toughness is decreased and risk of brittle fracture is increased; the stress intensity factor is plotted as a function of time for [ ] fuel assemblies in Figure 5. This factor is compared to the critical stress intensity factor of 25000 psi$\sqrt{\text{in}}$, in Table 4.1. (a,c)

TABLE 4.1 - NON-OPERATIONAL

LOADING CONDITIONS

[ ] (a,c)

[ ] (a,c)

This analysis shows that for [ ] (a,c)

4.2 CONDITION 1 AND 2 LOADS

Evaluation of the stress levels for SAR Condition 1 and 2 events results in no limiting factors for fuel assembly use through at least [ ] (a,c) The study evaluated a worst-case condition of [ ] (a,c)

Table 4.2 summarizes the stress values for Conditions 1 and 2.

End-of-life stresses are membrane plus peak stresses at operating temperature. Stress intensity limits are the lesser of 2/3 S_y or 1/3 S_u at operating temperature for primary membrane stresses and 3 times these values for total primary plus secondary stresses. [ ] (a,c)

TABLE 4.2 - CONDITIONS 1 AND 2

[ ] (a,c)

FUEL ARRAY	WORST* WEAR DEPTH %	MAXIMUM STRESS (psi)	STRESS INTENSITY LIMIT (psi)
[			] (a,c)

4.3 CONDITIONS 3 AND 4 LOADS

Evaluation of the stress levels for SAR Conditions 3 and 4 events result in no limiting factors for fuel assembly use through [ ] (a,c)

Table 4.3 summarizes the stress values for Conditions 3 and 4.

Stresses are membrane plus bending. Stress intensity limits are the lesser of 2.4 S_y or 1.05 S_u for primary membrane plus bending at operating temperature.

Margins are shown to be acceptable for [.] (a,c)

TABLE 4.3 - CONDITIONS 3 AND 4

[ ] (a,c)

[ ] (a,c)

5.0 CONCLUSION

Based upon the control rod guide thimble tube wear predictions presented in this report, it is shown that the integrity of the guide thimble tubes is maintained during normal operation, accident conditions and non-operational loading conditions for [ ] of fuel assembly operation. (a,c)

Several conservative assumptions were used and have been presented in Section 4; these conservative assumptions, the calculated margins and past operating experience provide sufficient evidence that the control rod guide thimble tube wear is not a safety concern in Westinghouse plants.

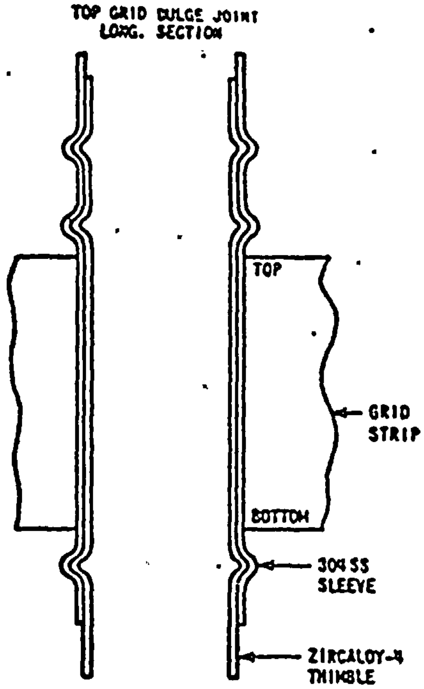
Figure 1

(a,c)

Figure 2

The handling load is applied to the top nozzle and transmitted from the top nozzle to the thimble tubes through the stainless steel sleeve.

(a,c)



The Zircaloy-4 thimble tube is connected to the top nozzle through a stainless steel sleeve. The thimble tube is fastened to the sleeve by means of bulge joints.

Figure 2 - [ ] (a,c)

Figure 3

(a,c)

Figure 4

On this figure, the RCC is in the fully inserted position, the RCC is resting on the adapter plate. When the RCC is fully withdrawn, the absorber rodlet is guided by the upper guide tube split tubes or sheaths and the rodlet tip is below the top grid.

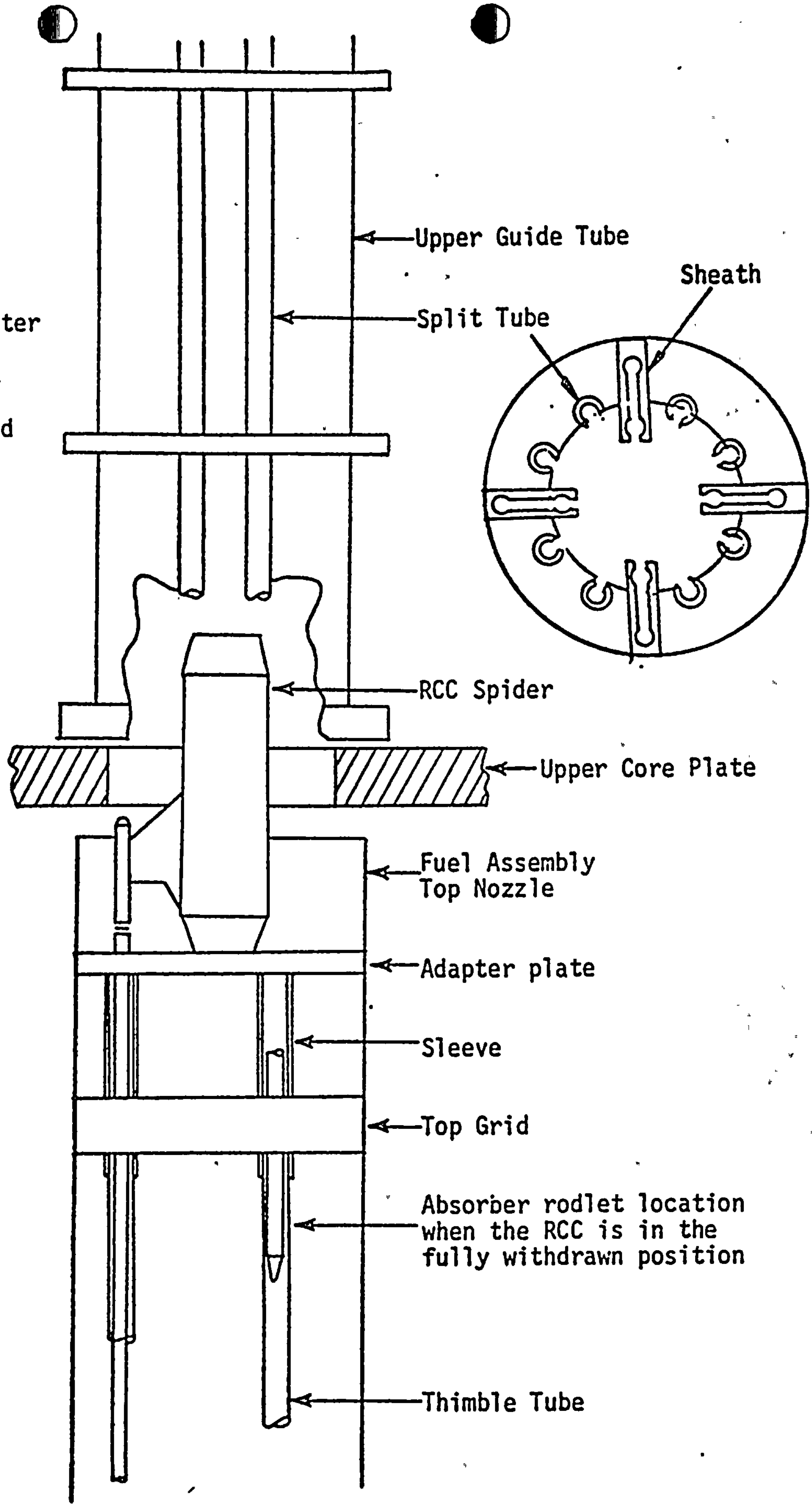
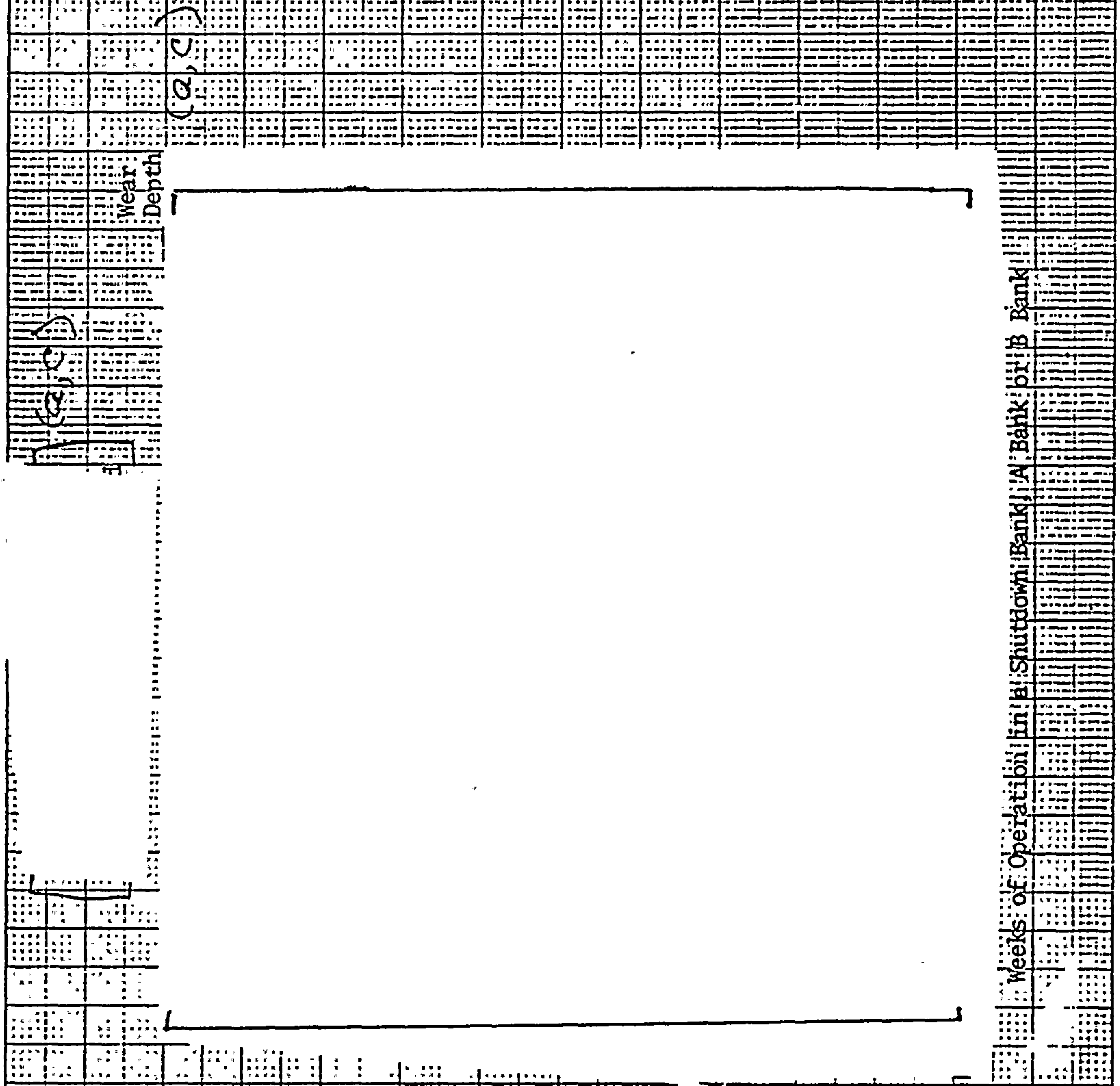


Figure 5 Comparison of Predicted and Measured Values for [ ] Fuel (a,c)
Assembly Guide Thimble Wear



46 1320
K+E 10 X 10 TO ½ INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN USA

(a,c)

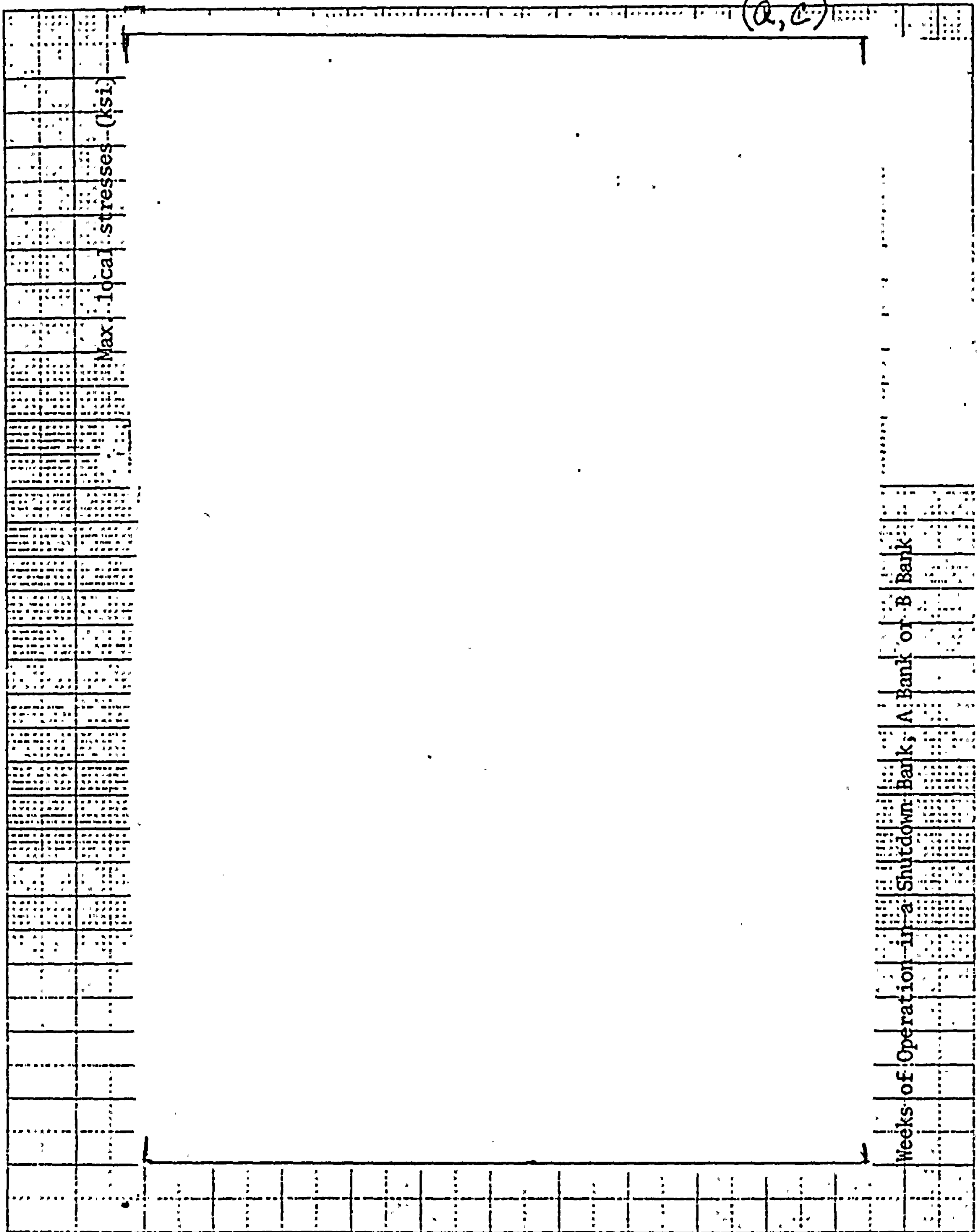


Figure 6 Guide Tube Wear and Stresses

K+E 10 X 10 TO 1/2 INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN USA
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