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October 22, 1985

Dr. R. O. Meyer
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Ralph:

The purpose of this letter is to convey background information which guided my recommendation to reduce the CORSOR release rates for Ag, In, and Cd from control rod alloy in severe accident situations. The current model in CORSOR for control rod component release (hereafter referred to as the Old CORSOR model) has calculated higher releases than found experimentally in recent bundle-type experiments. I have prepared and enclosed three figures which demonstrate this.

Figure 1 shows the total percentage release of Cd as a function of maximum temperature. The CM tests are George Parker's 1-kg bundle tests. The TMI-2 estimate is my own. The old CORSOR calculation does not look too bad, but I have recommended a reduction to 70% of the original which is shown as the New CORSOR line. The Surry TMLB' calculation is from NUREG-0956 DRAFT. An advantage of the above simple 70% reduction is that one can immediately see the effect on previous calculations made with the Old CORSOR model.

Figure 2 shows the total release of Ag as a function of maximum temperature. In this case there is a much bigger difference between the Old CORSOR and experimental releases. The TMI-2 estimate was obtained for me by Dan Osetek. As a result of this comparison, I have recommended that the silver release fractions in the Old CORSOR model be reduced by a factor of 10.

Figure 3 shows the ratio of Cd to Ag released. Note that this is on a weight basis and that Parker's tests contained material with a higher initial Cd to Ag ratio. Data from Hagen's bundles are available for this comparison, but he did not determine total Ag and Cd releases (SFD meeting in Idaho, April 1985). Since that meeting I talked with Hagen by phone. He said that he had no way of measuring total releases because there was so much deposition of material in the bundle proper. Parker's apparatus is better suited to collecting all the material released from his control rods. The point labeled 10 kg CM is from George Parker's 10 kg bundle.

The main reason that the Old CORSOR calculations result in such high releases is that runoff of the alloy is not accounted for. Bob Wichner, the architect of the old model, said that it is "sized" for releases from material maintained at the stated maximum temperature as in SASCHA tests. A recent test, HS-4, by M. F. Osborne, gave 31–60% release of Ag at 2000°C and 100% release at 2400°C. This test was run in the horizontal hot-cell fission

product release apparatus and the melted control rod was captive at the above temperatures. It agrees with the Old CORSOR model.

Alternatives to the Old CORSOR Model. As mentioned above, the recommended alternative is simple reduction of the Ag, Cd, and In fractional release amounts. This was chosen because of the minimum of computer programming required combined with a need to make the change quickly and without the luxury of test runs on the computer. It was also recognized that additional data would be available soon and that it would be best to wait for these data in order to be able to devise the most appropriate final model. Several possible changes in model type or coefficients that were considered are discussed below.

Vaporization Model. My recommendation in ORNL/TM-8842, the review of the computer codes, was that a vaporization model be used for the release (vaporization) of control rod alloy and structural materials from an overheated core. This is still my position, but I realize that extensive reprogramming in CORSOR would be required and that time for this is not available right now. In Fig. 3 are included two curves showing the ratio of partial pressures of Cd and Ag. These are essentially the same as the weight ratios. Their correspondence with the majority of the experimental data strongly supports the vaporization model concept.

Fractional Release Rate Model. By this I mean the use of the same type model used in CORSOR for fission product element release. This was used in NUREG-0772 for structural materials as well as fission products, but there was no release calculation at all for control rod species. In ORNL/TM-8842 I suggested some ways of modifying the simple fractional release rate model to compensate for irregular initial distribution (control rods are not in most fuel bundles) and for runoff. This approach was not recommended for use at this time because of the limited time available and the lack of certainty that it would be significantly better than a simple change in the Old CORSOR model for control rod alloy release.

Total Release vs Maximum Temperature Model. This is the model currently used in CORSOR. As mentioned above, the biggest deficiency with this model as presently used in CORSOR is that there is no provision for runoff. It is now very clear from the tests of Parker and Hagen that most of the alloy does run down to cooler regions of the bundle or core.

One possible change in the Old CORSOR model would be to write in provisions for movement of alloy from one region to another. This would be a major improvement and would be needed with almost any model in order to describe the alloy behavior correctly. It was rejected because of the programming time required.

A second corrective measure that was considered was to specify the initial location of the alloy as that expected for it after melting and runoff. This would eliminate the need for relocation during the computer run and would give essentially the same results. There is no provision at present for "non-uniform" distribution of materials.

A third "fix" considered was to keep the initial uniform alloy distribution but reduce it to about one-tenth of the real amount so that only a fraction would be exposed to the high temperatures of the main core regions. The remaining 9/10 or whatever fraction was deleted could be added manually after pressure vessel meltthrough and before Vanesa is started. This presented no problem since there was already a provision for such additions at the start of Vanesa.

The fourth change considered is the one that was ultimately recommended as being most appropriate at this time. It is to reduce the Ag and In releases to 10% of their previous values and to reduce the Cd release to 70% of the old model. Very little data are available for indium release; those that have been published support a close parallel with silver.

The selection of the above release reductions was made in August before some of the data shown in Fig. 3 was available. The decision on silver release was difficult. More weight was placed on release at high temperature (which controls total release during the accident) than on the early stage low temperature release. It has long been recognized that aerosols serve to transport fission products and that silver may be one of the important carriers. With the above reductions in release fractions, the resulting aerosol is still very rich in silver at the low temperatures but is not too far off toward the end of a high-temperature accident. An additional reduction in silver release should be considered.

The following people were consulted about control rod alloy behavior. Their advice and assistance is appreciated, but the listing of their names does not imply any endorsement or agreement with the above recommended changes to CORSOR.

Pete Cybulskis, BCL
S. Hagen, KfK
D. T. Osetek, EG&G
G. W. Parker, ORNL
R. P. Wichner, ORNL
R. O. Meyer, NRC

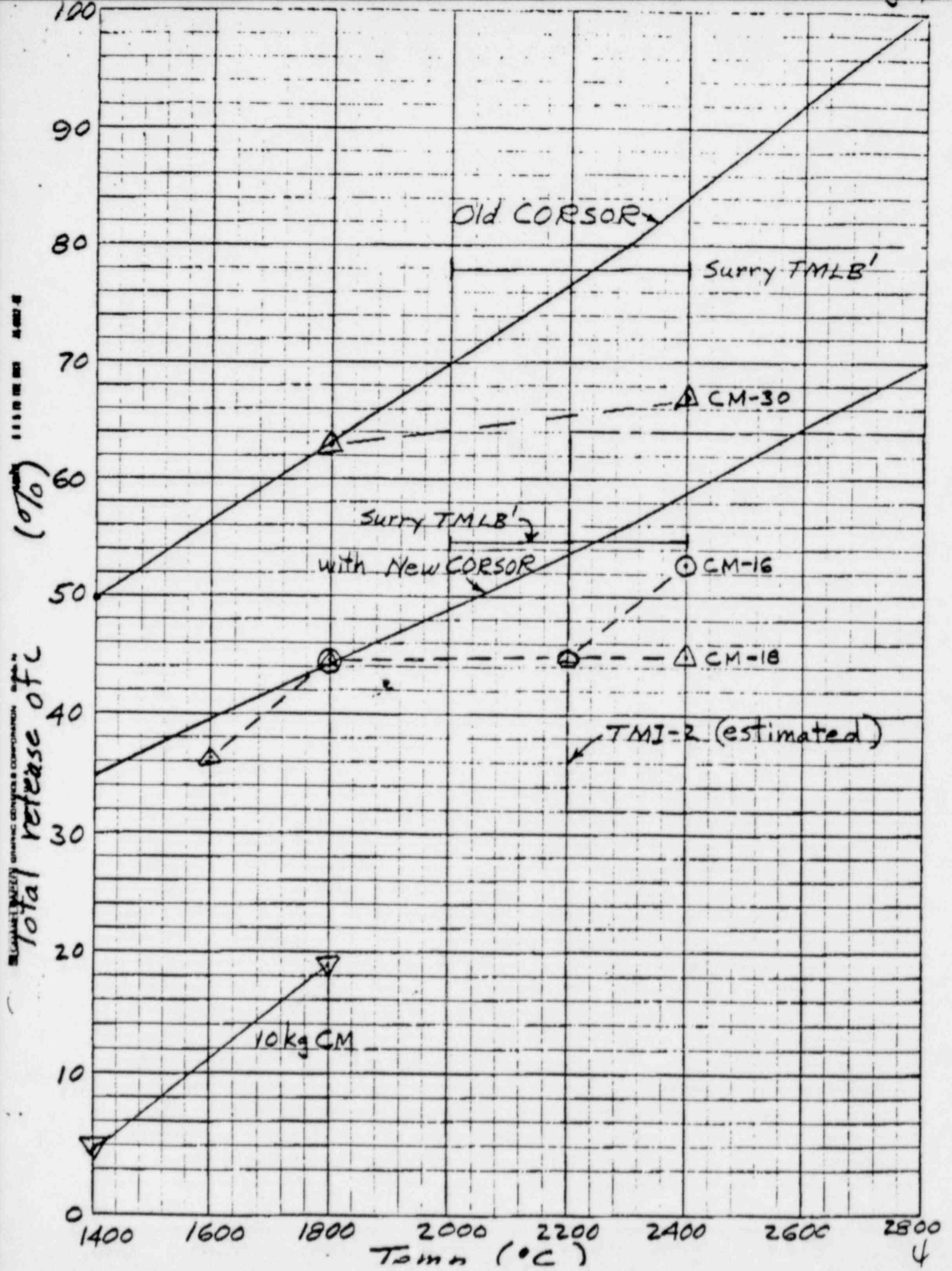
Sincerely,

R. A. Lorenz

R. A. Lorenz
Chemical Development Section
Chemical Technology Division

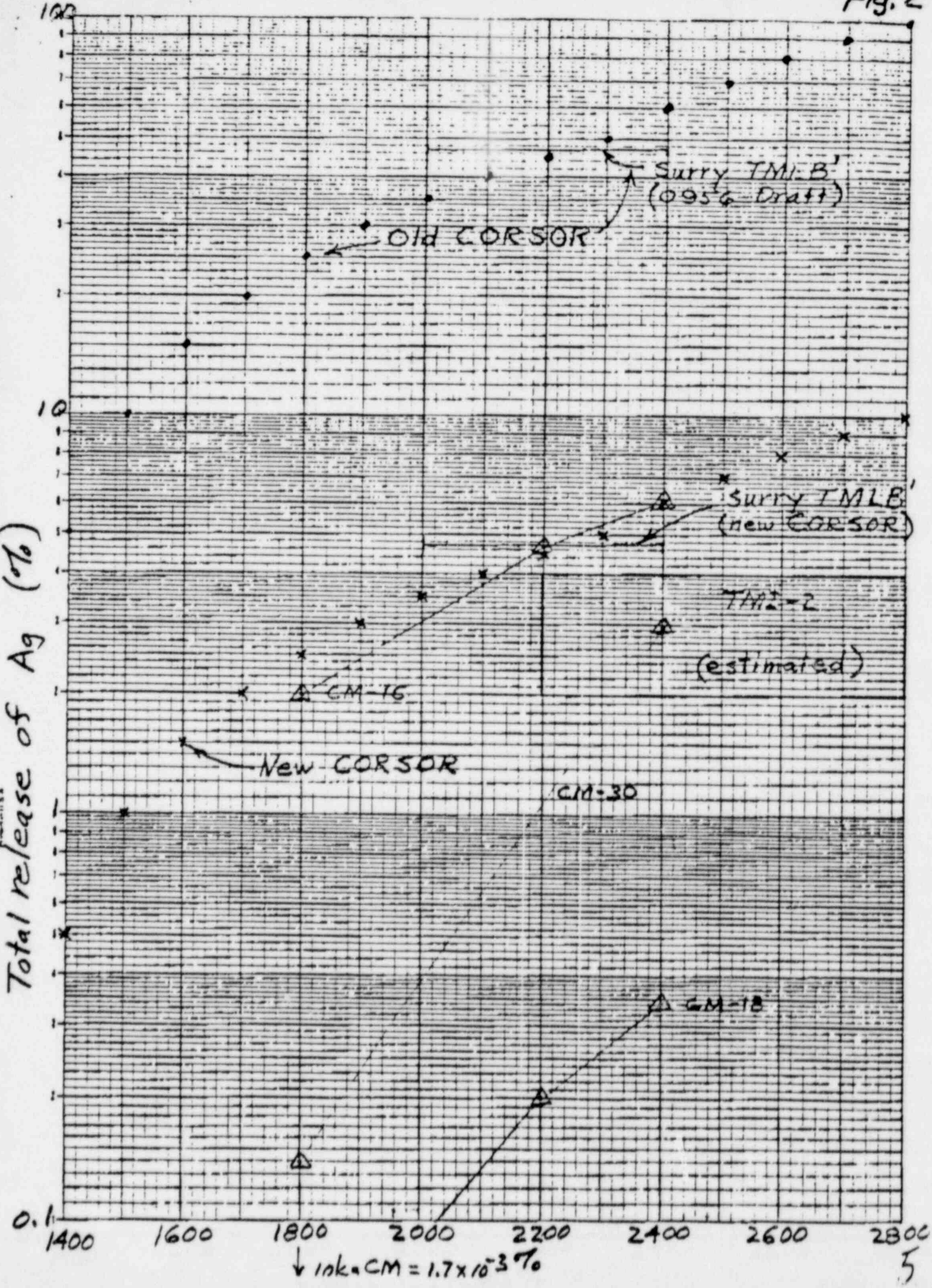
RAL:bcd

Enclosures: Figs. 1-3



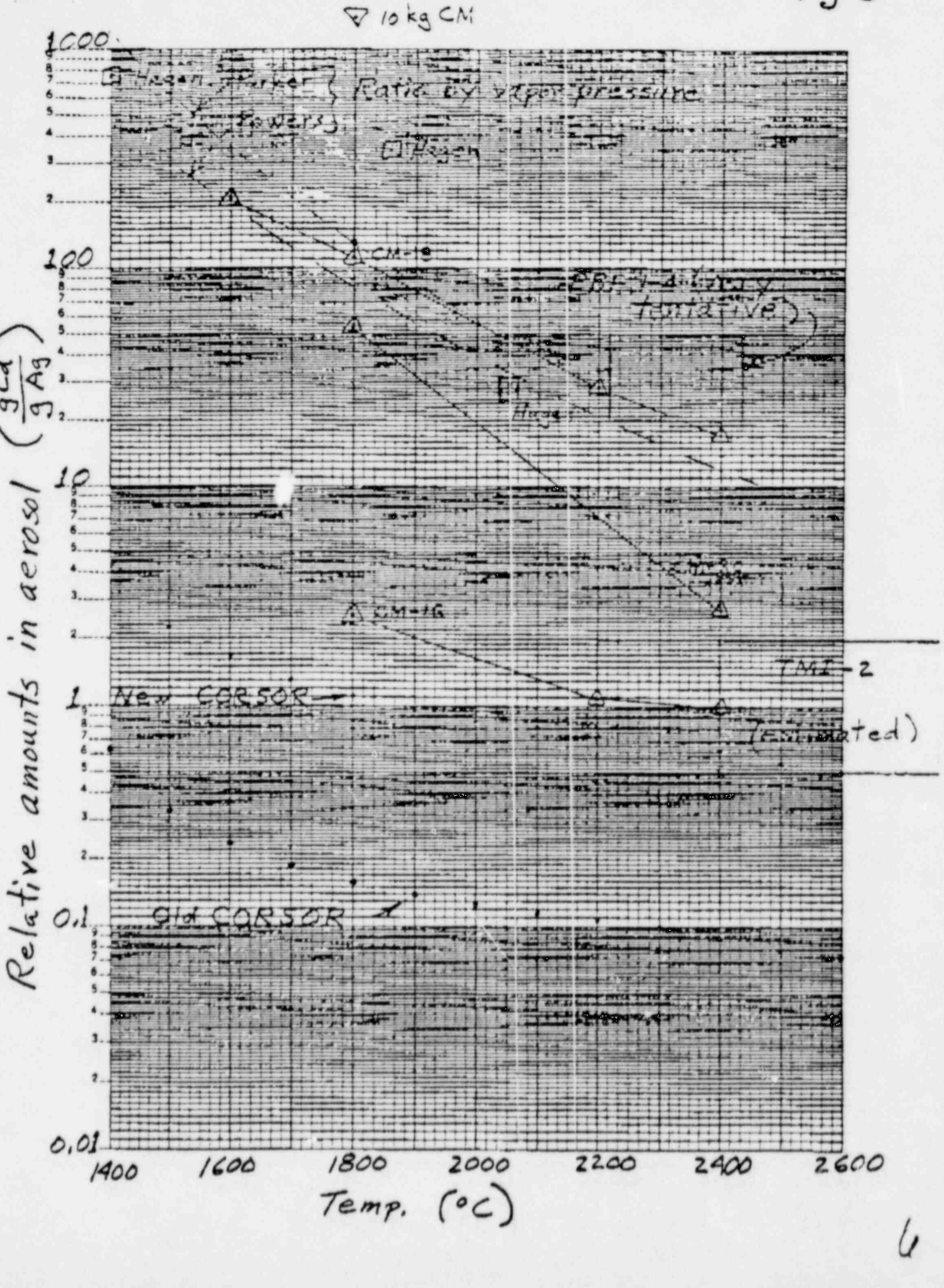
Total release of C (%)
Tomn (°C)
Old CORSOR
Surry TMLB'
CM-30
Surry TMLB'
with New CORSOR
CM-16
CM-18
TMI-2 (estimated)
10 kg CM
0
10
20
30
40
50
60
70
80
90
100
1400
1600
1800
2000
2200
2400
2600
2800

Fig. 2



100
10
1
0.1
Total release of Ag (%)
Surry TML-B'
(0956 Draft)
Old CORSOR
Surry TMLB'
(new CORSOR)
TMI-2
(estimated)
CM-16
New CORSOR
CM-30
CM-18
1400
1600
1800
2000
2200
2400
2600
2800
↓ ink. CM = 1.7×10⁻³ %

Fig. 3


▽ 10 kg CM
□ Hagen, Parker, Powers } Ratio by vapor pressure
□ Hagen
CM-18
CM-16
EBR-II Array (tentative)
Hagen
TMI-2 (estimated)
New CORSOR
Old CORSOR
1000
100
10
1
0.1
0.01
1400
1600
1800
2000
2200
2400
2600
Temp. (°C)
Relative amounts in aerosol (g Cd / g Ag)
K·E SEMI-LOGARITHMIC 5 CYCLES x 72 DIVISIONS
KEUFFEL & ESSER CO.
46 6293