January 27, 1995

Docket No. 040-08984

MEMORANDUM TO: Charles E. Gaskin, Licensing Project Manager,
Division of Fuel Cycle Safety and Safeguards

FROM: John D. Kinneman, Chief, Site Decommissioning Section
Division of Radiation Safety and Safeguards, RI

SUBJECT: MAGNESIUM ELEKTRON, INC.

References:
1. Shankman, NRC RI memo to Pierson, NMSB, dated June 10, 1994
2. Jaeger, MEI letter to Gaskin, NRC, dated September 20, 1994
3. ORISE Draft Report-Radiological Survey of the Magnesium Elektron Facility, Flemington, NJ, dated December 22, 1994

On September 20, 1994 Richard F. Jaeger of Magnesium Elektron, Inc. (MEI) sent you a letter discussing the results in S. Shankman's memorandum to Pierson dated June 10, 1994. We have carefully reviewed that letter and our original memorandum, the original data generated by the Region I Laboratory, and completed additional analyses. Our comments and conclusions are given in Attachment 1.

Attachment 2 is a summary of the visit by Region I staff to the MEI facilities in Aspers, PA and Flemington, NJ in October 1994. This includes the Region I analytical results of four samples of zircon feed material that were taken for ORISE by Region I at the MEI facility in Aspers, PA on October 4, 1994.

Attachment 3 is the Region I comments on the ORISE Draft Report for the Magnesium Elektron Inc. (MEI) Facility, dated December 22, 1994. We provided these comments to you previously.

Region I continues to believe that the MEI facility in Flemington requires an NRC license. Our bases are as follows:

The ORISE draft report provides sufficient data to support licensing of the MEI facility in Flemington, NJ, given the radionuclide concentration of material in Pond 1E, regardless of the moisture content of the material.

While gamma spectrometry results for the zircon sand are above 0.05% source material by weight and alpha spectrometry and neutron activation results are below 500 ppm it is clear that the feed material is very near the 500 ppm limit.

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The ORISE alpha spectrometry results for the liquid effluents (220 and 230 pCi/l) are a significant fraction of the 10 CFR Part 20, Appendix B, Table 2 limit (300 pci/l for U-238) for liquid effluents to the environment, but well below the Appendix B, Table 3 monthly average concentration limit (3000 pCi/l for U-238) for sewage disposal. In order to apply the sewer limit the solubility of the U-238 must be examined and the yearly volume discharges must be estimated to ensure that the annual one Curie limit for sewage disposal is not exceeded. In addition, it is not clear that this discharge meets NRC policy for sewer discharges (through a conduit to the sewer plant). In any case, the environmental effects of this operation are similar to a licensed operation.

While we have a clear opinion, we recognize this is a difficult policy decision and have attempted to provide in the attachments as much information as possible for the individual making the decision.

If you have any questions concerning our analyses or our comments, please contact John Kinneman at (610) 337-5252 or Marie Miller at (610) 337-5205.

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Attachments:
1. NRC Comments Re: MEI Letter Dated September 20, 1994
2. Summary RI Analysis Data from taken on October 4, 1994
3. Comments on Draft ORISE Report
4. Criteria for Comparing Analytical Measurements

cc: (w/enclosures)
J. Austin, NMSS
J. Glenn, NMSS
R. Pierson, NMSS
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ATTACHMENT 1

REGION I RESPONSE TO MEI LETTER DATED SEPTEMBER 20, 1994

In a letter to C.E. Gaskin dated September 20, 1994, Magnesium Elektron, Inc. (MEI) questioned the NRC Region I sample analyses described in the Region I memorandum from Shankman to Pierson dated June 10, 1994. The three primary issues raised by MEI are:

1) The inconsistency of the NRC Region I gamma spectrometry results for the zircon flour sample taken on April 7, 1994 in comparison to neutron activation analysis by MEI's supplier and gamma spectrometry results by ATI, MEI's contractor;

2) The analysis of dried sludge versus analysis of the wet sludge, since the sludge possessed by MEI is wet; and

3) The unusual levels of uranium daughters reported by the NRC Region I laboratory.

We have carefully reviewed the technical arguments raised by MEI and provide the following information and comments. Since we have the draft ORISE report of the sampling at MEI during October 1994, we have reviewed that draft and include our comments that are relevant to the above issues.

Issue One: Neutron Activation Analysis versus Gamma Spectrometry Results

MEI provided historical certificates from their vendor which state that total source material in their zircon sand feed has consistently been lower than 500 ppm. For the sample of zircon flour which Region I took in April 1994 the supplier reported a result of 157 ppm thorium and 275 ppm uranium while Region I reported 167 and 636, respectively. A reanalysis by GAA for MEI found 111 and 319, respectively. We agree that neutron activation analysis is a reliable method to determine uranium and thorium concentrations, and we are unable to completely resolve why our data for uranium-238 based on gamma spectroscopy disagree with the neutron activation analysis.

However, we carefully examined the data from the gamma spectral analysis of one zircon flour sample obtained at Aspers, PA on October 4, 1994 and split between the NRC and ORISE, and from the analysis of the zircon flour sample obtained at Flemington, New Jersey on April 7, 1994 analyzed by NRC and by MEI's contract laboratories ATI and GAA. We requested and received the specific isotope data for the April 7 sample from ATI in November 1994, and for the October sample from ORISE in December 1994, and developed Tables 1-1 and 1-2. This comparison is discussed below.

All three laboratories determine protactinium 234m (Pa-234m) by measuring the 1,001 keV photo-peak. ATI and NRC use a branching ratio for this photo-peak of 0.59% while ORISE uses 0.84%. MEI contends that although it is common to use this low abundance gamma emission from Pa-234m, it could cause errors, because the actual decay scheme for Pa-234m is not well known and the reported gamma ray abundances vary by a factor of two or more in published literature.

Our review of the literature shows that the 0.59% ratio is more widely encountered in gamma-ray intensity listings; the 0.84% ratio is sometimes selected because it correlates to field measurements better.

Both the Region I Laboratory and ORISE calculate U-238 on the basis of the measured concentration of Pa-234m and assuming the Pa-234m is in equilibrium with the U-238. ATI calculates U-238 based on the measured concentration of Pb-214 and assuming that the decay chain is in equilibrium (an assumption which is contradicted by their own data). The use of the Pa-234m , which is closer to the parent (U-238) seems more appropriate then a daughter product that is further down the decay chain. In addition, using a daughter product that is below radon-222 introduces possible losses from radon loss. Our use of this approach in the past has produced results that agree well with alpha spectral analysis for soils containing U-238.

The GAA neutron activation result from the April 7, 1994 sample is in agreement with the ATI gamma analysis based on the Pb-214 (and Bi-214) gamma analysis. Region I and ATI's Pa-234m values are in good agreement. Region I's Pb-214 and Bi-214 values agree well with ATI's values and the neutron activation results. Good agreement of neutron activation results to the daughter products further down the decay chain, yet poor agreement with results closer to the parent isotope is not easy to explain. This is especially true given MEI's statement that the equilibrium between the parents of the decay chains and their decay products is expected to remain undisturbed in the zircon sand. The thorium decay chain appears to be in equilibrium and the thorium data correlates well for all samples. Sample results were compared and agreement determined using the criteria contained in NRC Inspection Procedure 84750 (Attachment 4 provides the method for comparing laboratory analytical data).

As reported in the draft ORISE report, ORISE analyzed the October sample by alpha spectrometry and found 88 $\pm$ 12 pCi/g U-238 and 16.3 $\pm$ 9.9 pCi/g Th-232. These alpha spectrometry results correlate better than the gamma spectrometry results with the historical neutron activation analyses both in absolute numbers and with the reported 2:1 ratio of uranium to thorium. While the alpha spectrometry and neutron activation analyses compare well, the gamma spectrometry results are also statistically similar.

Another method of determining the U-238 concentration is to multiply the measured U-235 concentration by 21.9. U-235 is determined using the 143 kev photo-peak and the decay scheme is well known. For these samples the U-235 determination has an uncertainty of between 10 and 20 per cent. For the April 7 sample Region I calculates a U-238 concentration of 162 pCi/g using Region I data and 149 pCi/g using ATI data. For the October sample Region I calculate 131 pCi/g using Region I data and 103 pCi/g using ORISE data.

Since we are not able to resolve why the gamma analyses are generally above the 500 ppm licensing criteria and the alpha analyses are generally lower than 500 ppm, a sample of zircon sand might be analyzed by neutron activation by an independent laboratory to serve as a referee method.

Issue Two: Dried Sludge versus Wet Sludge Analysis

MEI indicates they do not understand "...the Region's purpose in attempting to measure concentrations in dried material..." The reason we measured the concentrations in dried material is that, as discussed in the June 10, 1994 memorandum, the material does dry in air under normal conditions. Unless the material is maintained wet by keeping it in an impoundment and adding water or holding rain water, it appears that the material will become dry and soil-like. We continue to believe that NRC decisions should be made on the concentrations in the dry sludge because it is what the material may become unless maintained under controlled conditions.

We do not dispute MEI's testing and the ORISE results that demonstrated that the material is naturally hygroscopic. However, even MEI recognizes that the "sludge could be converted into licensable (emphasis added) source material by drying or other methods of concentration", except for their intentions not to allow this to happen.

Issue Three: Variability of Uranium Progeny in Sludge Samples

MEI states that "the Region's results are also highly suspect because of the unusual levels of uranium daughters reported by the Region."

The data presented in Table 1-2 shows that the NRC data and the ATI data are not substantively different except that NRC reported Ra-226 while ATI did not. The NRC Ra-226 values were corrected for U-235 interference at the 186 keV peak used to quantify the Ra-226, resulting in a rather large uncertainty. MEI's comments regarding the fact the Ra-226 value reported is less than the Pb-214 and Bi-214 values, failed to consider the uncertainty of the Ra-226. When this uncertainty is considered, the Ra-226 value and the Pb-214 and Bi-214 results overlap. The data in Table 1-2 was available to MEI, yet they did not compare their Bi-214 and Pb-214 results directly to the NRC results. Since the MEI data closely agrees with the NRC data with the exception of the Ra-226, which is not reported by MEI, the comments made by MEI about the NRC data also apply to their gamma spectrometry data. Whether the analyst uses a branching ratio of 0.59 or 0.84, it appears that there is consistently a greater concentration of Pa-234m (or less of the daughters) in these samples than one would expect at equilibrium.

"The Region's measurements...in Pond 1 East exhibit similar inconsistencies." With respect to Ra-226, ORISE had reported in their January 28, 1994 letter to you based on the split samples from Pond 6 that were dried, that in most solid samples, the Ra-226 level is higher than the U-238 level, with water samples showing insignificant concentrations of the decay series daughters. Since the material for Pond 1 East has been freshly processed, it does not seem unusual to us that the equilibrium is disrupted. We have carefully rechecked our sample results and believe them to be accurate.

Conclusion

Region I's gamma spectrometry measurements agree well with other laboratories using this technique. There is disagreement on the most appropriate method of determining U-238 from the measured results. Neutron activation analysis and alpha spectrometry produce lower U-238 results than gamma spectrometry analyses. While Region I has found good correlation among these techniques in the past, these materials (the sand, flour and the sludge) are different from previous samples evaluated by Region I.

We agree with MEI that neutron activation analysis should be a reliable indication of the concentration of uranium and thorium and that these results should be consistent with Region I analyses. We intend to continue to evaluate our analytical methods to determine the most appropriate technique for measuring uranium in all samples. Most of the analyses reported for the samples are statistically similar.

It is not clear which method produces the "best" results. It is apparent that the zirconium feed material is near 500 ppm source material and that some of the sludge exceeds this value.

TABLE 1-1
COMPARISON OF NRC AND ORISE DATA

Sample: MEI - Zircon powder **Sample Date: October 4, 1994**

ANALYSIS	NRC RI LAB pCi/gram	ORISE pCi/gram	RATIO ORISE/NRC	AGREEMENT
Pa-234m [1]	190 ± 20	Not reported	N/A	N/A
Pa-234m [2]	133 ± 20	127 ± 18	0.95	A
Ra-226	86 ± 10	Not reported	N/A	N/A
U-235	6.0 ± 0.6	4.7 ± 0.7	0.78	A
Pb-214	103.5 ± 0.4	100.6 ± 0.6	0.98	A
Bi-214	93.3 ± 0.4	90.6 ± 0.6	0.97	A
Ac-228	15.7 ± 0.4	14.4 ± 0.6	0.90	A
Pb-212	14.34 ± 0.14	13.4 ± 0.2	0.94	A
Bi-212	8.8 ± 0.7	Not reported	N/A	N/A

Remarks: Agreement determined from Criteria for Comparison (Attachment 4)

[1]Pa 234m at 0.59% abundance

[2]Pa-234m at 0.84% abundance

TABLE 1-2
NRC AND ATI DATA

Sample: MEI - Zircon powder **Sample Date: April 7, 1994**

ANALYSIS	NRC RI LAB pCi/gram	ATI pCi/gram	RATIO ATI/NRC	AGREEMENT
Pa-234m [3]	210 ± 20	236 ± 14	1.12	A
Ra-226	78 ± 15	Not Reported	N/A	N/A
U-235	7.4 ± 0.9	6.8 ± 0.7	0.92	A
Pb-214	106 ± 6	108 ± 3	1.02	A
Bi-214	96.7 ± 0.6	103 ± 3	1.06	A
Ac-228	18.4 ± 0.7	16.8 ± 0.7	0.91	A
Pb-212	16.3 ± 0.2	17.8 ± 0.6	1.09	A
Bi-212	10.9 ± 0.9	12.6 ± 1.0	1.16	A

Remarks: Agreement determined from Criteria for Comparison (Attachment 4)

[3] Pa-234m at 0.59 abundance

ATTACHMENT 2

SITE TOUR AND SAMPLING AT MEI FACILITIES AT ASPERS, PA AND FLEMINGTON, NJ

1. OBJECTIVES

The purpose of the licensing visit at Aspers, PA, and Flemington, NJ, was to take split samples at Aspers, PA, for analysis by ORISE and NRC RI, observe the sampling conducted by ORISE at the Flemington facility, and to become familiar with the two facilities. As part of the evaluation to determine if the activities at MEI should be licensed by NRC, additional data was needed to determine the concentrations of thorium and uranium throughout the MEI process, including the incoming zircon sand, the zirconium chemical separation process and the process sludge contained in the on-site storage ponds.

2. SAMPLING

Sampling was conducted on October 4, 11, and 12, 1994 in accordance with the ORISE radiological survey plan submitted to NRC on September 24, 1994. The process at Aspers is simple, with only a portion of the site used by MEI for zirconium sand processing. The zirconium sand is transferred from a storage silo by conveyor and is ball milled into a zircon flour, with an intermediate loop that recirculates a portion of the load with air.

The samples of feed material at Aspers were from Lot ZES976 that was received at Aspers by truck on October 3, 1994. These samples were split between ORISE, NRC RI, and MEI. The results of these samples are listed in Table 2-1(a) with the relevant isotopes reported in Table 2-1(b). A comparison of the recirculated load sample to the ORISE split sample result; and a comparison to an earlier zircon flour sample analyzed by NRC RI and MEI's contractor laboratory, Analytical Technologies, Inc. (ATI) is also shown in Attachment 1, Tables 1-1, and 1-2, respectively.

ORISE conducted split sampling with MEI at the Flemington, NJ facility on October 11-12, 1994. Region I observed the sampling on October 11, 1994 and also took three liquid samples from the discharge of Pond 8 at the tanker loading station. The liquid effluent is trucked to the off-site Trenton Municipal Utility Authority (MUA) where it is treated in their sewerage treatment facility. The MEI representative stated that usually 350,000 gallons per week are shipped, but dependent on the amount of rainfall, as much as 200,000 gallons per day have been transported. NRC Region I samples of the liquid effluent were split with MEI, but ORISE took split liquid samples with MEI on the following day. The results of the liquid effluent samples are listed in Table 2-2.

3. RESULTS AND INTERPRETATION

The zirconium sand and zircon flour (feed material) samples were dried, weighed, and then analyzed using a high resolution gamma spectrometry system. For determination of thorium and uranium by gamma spectrometry, Region I reports thorium and uranium on the basis of Ac-228 and Pa-234m, respectively, with a counting uncertainty of one standard deviation.

The four sample results are statistically identical. Using an average U-238 concentration of 187 ± 20 pCi/g, and Th-232 average concentration of 16.9 ± 0.5 pCi/g, the material is greater than 500 ppm source material based on these measurements. The measurement of U-238 reported are based on the Pa-234m using a branching ratio of 0.59%.

The three liquid samples were collected, evaporated, weighed and analyzed on a Tennelec LB (low background) gas-flow proportional counter for gross alpha/beta. Results are shown in Table 2-2. The gross alpha/beta analysis is a screening tool and is not appropriate for quantitative assessment of U-238 in the effluent. Nevertheless, these results indicate the need for quantitative assessment of the radionuclide concentrations and evaluation against the liquid effluent and sewage discharge limits. Further investigation of this material should be considered, given the large volume released from MEI, and potential for reconcentration of the material at the municipal sewage treatment facility.

TABLE 2-1 (a): RADIONUCLIDE CONCENTRATIONS IN ZIRCON SAND FROM ASPERS,PA

PROCESS MATERIAL	SAMPLE WT (g)	U-238[1] (pCi/g)	Th-232 (pCi/g)	COUNT TIME (sec)
#1 Zircon Sand/Silo	675	200 ± 20	17.1 ± .5	3000
#2 Zircon Sand/Silo	701	180 ± 20	16.5 ± .5	3000
#3 Zircon Sand/Recir	577	190 ± 20	15.7 ± .4	5000
#4 Zircon Flour	395	180 ± 20	18.3 ± .6	5000

TABLE 2-1(b)
NRC ANALYSIS DATA

Sample: MEI - Zircon Feed Material **Sample Date: October 4, 1994**

ANALYSIS	Sample 1 pCi/gram	Sample 2 pCi/gram	Sample 3 pCi/gram	Sample 4 pCi/gram
Pa-234m[2]	200 ± 20	180 ± 20	190 ± 20	180 ± 20
Ra-226	88 ± 9	107 ± 12	86 ± 10	94 ± 12
U-235	5.8 ± 0.5	4.0 ± 0.7	6.0 ± 0.6	6.8 ± 0.7
Pb-214	104.0 ± 0.5	98.5 ± 0.4	103 ± 0.4	109.8 ± 0.5
Bi-214	96.9 ± 0.5	90.4 ± 0.5	93.3. ± 0.4	100.6 ± 0.5
Ac-228	17.1 ± 0.5	16.5 ± 0.5	15.7 ± 0.4	18.3 ± 0.6
Pb-212	15.8 ± 0.2	14.6 ± 0.2	14.4 ± 0.1	17.5 ± 0.2
Bi-212	10.4 ± 0.8	9.5 ± 0.7	8.8 ± 0.7	10.6 ± 0.8

TABLE 2-2: RADIONUCLIDE CONCENTRATIONS IN LIQUID EFFLUENTS FROM MEI

LIQUID SAMPLE	GROSS ALPHA dpm/ml	GROSS BETA dpm/ml
Tanker 1	7.1 ± 0.9	7.0 ± 0.8
Tanker 2	7.5 ± 0.9	7.4 ± 0.8
Tanker 3	8.2 ± 0.9	7.9 ± 0.8

[1]Based on Pa-234m

[2]Pa-234m at 0.59% abundance

ATTACHMENT 3

Region I Comments on ORISE Draft Report - Radiological Survey of the Magnesium Elecktron Facility, Flemington, NJ dated December 22, 1994

The draft report satisfies the Proposed Radiological Survey Plan for MEI dated August 31, 1994. However, the following changes should be made:

General Comments

ORISE is "... to determine the concentration of thorium and uranium throughout the zirconium separation process. The NRC will use the radiological data generated to make a defendable decision with regard to the licensing of the facility."(page 2) We agree. However, throughout the draft report ORISE compares results to NRC criteria. All such discussions should be deleted. We recognize that the proposed plan had stated that a comparison to NRC guidelines would be included, however this is not the role of ORISE. ORISE should focus on providing good data and explaining the limitations in the data. Appropriate NRC staff will decide whether the data indicates NRC criteria are exceeded or not.

Throughout the document "total radionuclide concentrations" or similar words are used when the "total source material concentration" is meant.

Specific Comments

Page 2 Under Document Review, delete "... and comparison to the source material licensing requirements."

Page 5 Since the licensee has questioned which photo-peaks are appropriate for identification of U-238 (Letter dated September 20, 1994), we suggest that the peak(s) and abundance(s) used for identification of each isotope be listed.

Page 6 Delete "... and NRC guidelines established for licensable, etc." This is not ORISE's task.

Page 6 Delete the phrase "...since the NRC licensing regulation does specifically address whether wet or dry weights apply." This comment is not related to the ORISE task.

Page 7 ORISE should provide more discussion on the consistency of the alpha and gamma results for the zirconium sand and zircon flour samples. For example, "The results show that the sampling of the feed material was representative and that the differences in sample size for the two methods did not create the variations in the results. Comparison of the alpha to gamma results shows ...."

Page 8 Although we agree that the alpha and gamma spectrometry results are fairly consistent for the sludge, the difference should be quantified and discussed. For example, do the results suggest non-representative sampling? Is the sample size for alpha

analysis appropriate (it is likely much smaller than that used for gamma spectrometry) given the fact that the concentration of source material in this media seems highly variable?

Page 8 Delete "... allowing for more definitive conclusions relative to licensing criteria (i.e., radionuclide concentrations in Pond 1E exceed the licensing criteria on both wet and dry basis)."

Page 8 "Comparison of Results with Guidelines" subsection should be renamed "Interpretation of Results" and changed to a discussion of the data and which results are most reliable. All comparison to NRC regulatory criteria and decisions should be deleted.

Page 9 Statements on this page are contradictory and not supported. The explanation that the gamma spectrometry analyses overestimate the radionuclide concentrations "due to efficiency for higher energy gamma emissions being underestimated" is not supported. Comparing NRC RI data to ORISE data, for one sand sample, as shown in Table 1-1, we find no evidence of calibration problems, of which efficiency is a factor. For example, if there was a detector efficiency problem, the thorium peak identification used for the gamma result would not be consistent with the alpha result.

Page 9 Delete the comparison of Pond 8 results to NRC standards for liquid effluents. Whether environmental limits (300 pCi/l) or sewage limits (3000 pCi/l) should be applied to this discharge is not clear. There are a number of conditions that must be met for the higher sewage limit to be applied, including release through public conduits, solubility, and an additional limitation of no more than a total of one Curie limit per year. In any case, that is an NRC staff decision.

ATTACHMENT 4

CRITERIA FOR COMPARING ANALYTICAL MEASUREMENTS

This attachment provides criteria for comparing results of capability tests and verification measurements. The criteria are based on an empirical relationship which combines prior experience and the accuracy needs of the program.

In these criteria, the judgement limits are variable in relation to the comparison of the NRC Reference Laboratory's value to its associated uncertainty. As that ration, referred to in this program as "Resolution", increases, the acceptability of a licensee's measurement should be more selective. Conversely, poorer agreement must be considered acceptable as the resolution decreases.

Resolution[1]	Ratio for Comparison[2]
<4	No Comparison[3]
4 - 7	0.5 - 2.0
8 - 15	0.6 - 1.66
16 - 50	0.75 - 1.33
51 - 200	0.80 - 1.25
>200	0.85 - 1.18

[1] Resolution = (NRC Reference Value/Reference Value Uncertainty)

[2] Ratio = (Licensee Value/NRC Reference Value)

[3] No comparison due to the large uncertainty in the NRC Reference Value.