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HUNT N PECK - A PROGRAM TO
PERFORM ZONE FLATTENING
CALCULATIONS ON THE IBM-7090

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HUNT N PECK - A PROGRAM TO
PERFORM ZONE LOADING
CALCULATIONS ON THE IBM 7090

I. INTRODUCTION AND SUMMARY

Presently, there is no standard technique in use by all assigned physicists to actually calculate required reactor loading changes. Basically, loading changes are made by determining the number of enrichment columns needed for equilibrium operation following startup; this is usually based upon past experience with relatively similar reactor conditions. Selection of locations for placement or removal of the enrichment then involves the application of information gleaned from temperature maps, previous experience, educated guesses, or a combination of the three.

This program is designed to assist the physicist in making accurate loading changes, thus optimizing his time and effort and therefore indirectly enhancing production efficiency. The program is not intended as a magical "one-all," but rather as a tool to be judiciously used to supplement the technical skill of the assigned reactor physicist.

The program is based on one-group, one-dimensional, diffusion theory. Local buckling effects caused by fission products, temperatures, and materials are calculated for many small zones of the reactor before and after a discharge. Loading changes are then designed to produce a central zone buckling of zero with the required supporting buckling of the enrichment ring; equal bucklings for all zones within a particular region are achieved by manipulation of the enrichment inventory in each particular zone.

This program is primarily designed for specific use by assigned physicists of the Pile Physics unit. Basic familiarity with the standard calculational techniques, nomenclature, and technical jargon of that group is necessary for effective application. Program input includes region geometry and material, plus reactivity variables; output consists of the enrichment required in each zone to maintain an optimized reactor loading with sufficient reactivity for adequate control. In addition, a printout of the case input is provided for reference.

This document includes a complete listing of all equations used in the calculations, as a basis for possible future revisions or modifications by a particular user for a particular case. In addition, a complete Fortran listing is included in the appendix.

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II. DISCUSSION

A. Nomenclature

The important equations and assumptions utilized by Hunt N Peck are presented for reference purposes. The following nomenclature is descriptive of the various quantities studied by the code:

B_i^2	Buckling of the i^{th} region
B_{Xe}^2	Local buckling effect of Xenon
B_{Sm}^2	Local buckling effect of Samarium
B_{Np}^2	Local buckling effect of Neptunium
B_H^2	Local buckling effect of Metal Heating
B_{LTG}^2	Local buckling effect of Long-Term-Gains
B_T^2	Local buckling effect of Graphite Heating
B_g^2	Local buckling effect of Axial Geometric Leakage
B_c^2	Local buckling effect of Controls
B_{NU}^2	Local buckling effect of Non-Uranium Columns
B_{MIX}^2	Local buckling effect of Water Mixers
B_N^2	Local buckling effect of Natural Uranium
B_E^2	Local buckling effects of Enriched Uranium
δB_{Xe}^2	Local buckling change of Xenon
δB_{Sm}^2	Local buckling change of Samarium
δB_{Np}^2	Local buckling change of Neptunium
δB_H^2	Local buckling change of Metal Heating
δB_{LTG}^2	Local buckling change of Long-Term-Gains
δB_T^2	Local buckling change of Graphite Heating
C_N	Tubes/Ton of natural uranium
C_m	Metal temperature coefficient

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C_T	Moderator temperature coefficient
$\frac{df}{df}$	Flux correction factor
δE	Exposure increment (MWD/Ton)
E_N	Exposure of natural uranium
E_E	Exposure of enriched uranium
f_1	Average factor of the i^{th} region
f_{cz}	Average central region factor
f_{Ni}	Fraction of natural tubes in i^{th} region
f_{NDi}	Fraction natural tubes discharged from i^{th} region
f_{Ei}	Fraction of enriched tubes in i^{th} region
f_{EDi}	Fraction enriched tubes discharged from i^{th} region
$\overline{mf}$	Material correction factor
N_p	Atomic concentration of Neptunium-239
P_m	Atomic concentration of Promethium-149
S_m	Atomic concentration of Samarium-149
t	Time (days) to gain δE exposure in central region
T	Outage length (days)
T_G	Moderator temperature ($^{\circ}C$)
γ_P	Fission yield of Promethium-149
$\overline{\Sigma}_a$	"Effective" macroscopic absorption cross section of fuel to produce Pu-239
Σ_f	Macroscopic fission cross section of fuel
λ_N	Decay constant of Np-239
λ_P	Decay constant of Pm-149
n_{49}	Grams/Ton of Pu-239
n_W	Grams/Ton of Np-239
W	Power level
ϕ	Neutron flux

B. General Program Details and Equations

Each of the reactivity transient effects integral to the program is discussed below; in general, the equations given represent the techniques utilized by the code to calculate and revise the various reactivity effects. For a more complete explanation of the basic theory involved in the equations used in the program, the reader is referred to other documentation.^{/1/}

1. Xenon

The equilibrium xenon local buckling effect is obtained from the following relation: ^{/3/}

$$[(B_{Xe}^2)_K]_i = [(0.11657)(W^*) / (1 + 0.001976(W^*))]_i \mu b \quad (1)$$

$$[(B_{Xe}^2)_{Old}]_i = [(0.18532)(W^*) / (1 + 0.003651(W^*))]_i \mu b \quad (2)$$

The power level term, W^* , is the flux weighted effective power, and therefore the recorded level must be corrected for the particular flux and material correction factors in the zone:

$$[W^*]_i = [(Pile Power)(Average factor)(\overline{df})(\overline{mf})]_i \quad (3)$$

where File Power = Power in megawatts

Average factor = Average zone factor

$\overline{df}$ = A flux correction term arising from the fact that xenon poisoning in a flattening pile is less than an unflattened pile.

$$= 1.388 - (.59)(Average factor)/10/ \quad (4)$$

$\overline{mf}$ = A material correction term (xenon buildup and power generation is different for enriched metal), which relates the fraction of natural and enriched metal.

$$[(mf)_K]_i = [f_N + 1.0206 f_E]_i / 1/ \quad (5)$$

$$[(mf)_{Old}]_i = [f_N + 0.869 f_E]_i \quad (6)$$

No time dependence was included in the xenon calculations; calculations were based upon assumed saturation xenon at shutdowns and at the specified time t , after a given incremental exposure δE , following startup. The program automatically corrects the xenon poisoning effect in a zone for any flux distribution shifts resulting from loading changes. This then is expressed in the following relation:

$$[\delta B_{Xe}^2]_i = [B_{Xe}^2 @ SD - B_{Xe}^2(t)]_i$$

2. Samarium^{/1/}

The calculation of the time dependent behavior of promethium and samarium begins with the basic equations:

$$\frac{dPm}{dt} = \gamma_p \Sigma_f \phi - \lambda_p Pm \quad (8)$$

$$Pm(t) = \gamma_p \Sigma_f \phi / \lambda_p + (Pm_0 - \gamma_p \Sigma_f \phi / \lambda_p) e^{-\lambda_p t} \quad (9)$$

Where $\gamma_p \Sigma_f \phi / \lambda_p$ is the equilibrium concentration of promethium.

Equation (9) may be rewritten as follows:

$$Pm(t) = Pm^E - (Pm^E - Pm_0) e^{-\lambda_p t} \quad (10)$$

Samarium, the daughter product of promethium, is formed according to the following equation:

$$\frac{dSm}{dt} = \lambda_p Pm - \sigma_s \phi Sm \quad (11)$$

$$Sm(t) = \gamma_p \Sigma_f / \sigma_s + [(\gamma_p Pm_0 - \gamma_p \Sigma_f \phi) / (\sigma_s \phi - \lambda_p)] e^{-\lambda_p t} + [Sm_0 - (\gamma_p \Sigma_f / \sigma_s) - (\lambda_p Pm_0 - \gamma_p \Sigma_f \phi) / (\sigma_s \phi - \lambda_p)] e^{-\sigma_s \phi t} \quad (12)$$

where $\gamma_p \Sigma_f / \sigma_s$ is the equilibrium concentration of samarium. This equation may be rewritten in simplified form, converting concentration terms to buckling terms:

$$B_{Sm}^2(t) = B_{Sm}^{2E} + (\overline{pf})(B)(\Delta Pm) - G[\Delta B_{Sm}^2 + (\overline{pf})(\Delta Pm)] \quad (13)$$

$$\text{where } \overline{pf} = \lambda_p / (\lambda_p - \sigma_s \phi) \quad (14)$$

$$B = e^{-\lambda_p t} \quad (15)$$

$$G = e^{-\sigma_s \phi t} \quad (16)$$

$$\Delta Pm = Pm^E - Pm_0 \quad (17)$$

$$\Delta B_{Sm}^2 = B_{Sm}^{2E} - B_{Sm_0}^2 \quad (18)$$

The equilibrium local samarium bucklings after evaluation of the constants are:^{1/}

$$B_{Sm}^{2E} = 9.999 \text{ } \mu\text{b} (K_{Nat}) \quad (19)$$

$$= 10.467 \text{ } \mu\text{b} (K_{Enr}) \quad (20)$$

$$= 8.867 \text{ } \mu\text{b} (\text{Pre-}K_{Nat}) \quad (21)$$

$$= 8.899 \text{ } \mu\text{b} (\text{Pre-}K_{Enr}) \quad (22)$$

The local samarium buckling effect at shutdown is then:

$$[(B_{Sm}^2)_K]_i = [9.999 f_N + 10.467 f_E]_i \quad (23)$$

$$[(B_{Sm}^2)_{\text{Pre-K}}]_i = [8.867 f_N + 8.899 f_E]_i \quad (24)$$

The calculation of the local samarium transient following startup is considerably more complex; the procedure applied in "Hunt N Peck" is described below.

The reactivity status of the reactor is mainly dependent on the exposure of the central region; accordingly, the time required to reach a given exposure value in the central region is determined. This time is then used in the time dependent portions of the samarium transient following startup. The time to gain a given incremental exposure in the central region is calculated from the equation:

$$t = (\delta E)(N_A)/(W)(f_{cz})(C_N)/11/ \quad (25)$$

where δE = exposure increment - MWD/Ton

N_A = Number of pile active columns

W = Pile power level -MW

f_{cz} = Average central region factor

C_N = Tubes/Ton of natural metal

The average neutron flux in a zone can be determined from the following relationship: ^{1/}

$$[\phi] = [(W)(f)(10^3)/(N_A)(\alpha)]_1 \quad (26)$$

where f = Average zone factor

N_A = Number of active tubes in zone

α = A proportionality constant applied to convert tube power to neutron flux. The appropriate α_1 term to use in the equation is found below: ^{1/}

$$[(\alpha)_K]_1 = [(4.915 f_N + 5.495 f_E)(10^{-11})]_1 \quad (27)$$

$$[(\alpha)_C]_1 = [(4.288 f_N + 4.593 f_E)(10^{-11})]_1 \quad (28)$$

$$[(\alpha)_{Pre-K}]_1 = [(4.342 f_N + 4.610 f_E)(10^{-11})]_1 \quad (29)$$

Equations 14-16 can now be evaluated:

$$[pf]_1 = [(0.3072)/(0.3072 - (5.7024 \times 10^{-12}))(W)(f)/(N_A)(\alpha)]_1 \quad (30)$$

$$B = e^{-0.3072 T} \quad (31)$$

$$[G]_1 = [e^{-(5.7024 \times 10^{-12})(\delta E)(f)/(f_{cz})(C_N)(\alpha)}]_1 \quad (32)$$

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The equilibrium promethium potential local buckling effect is then given by:

$$[(P_M^E)_K]_i = [(0.00156)(W)(f)]_i \quad (33)$$

$$[(P_M^E)_{Pre-K}]_i = [(0.00246)(W)(f)]_i \quad (34)$$

Equations 17 and 18 may now be written as follows:

$$[\Delta P_M]_i = [P_M^E - (1-f_D)(P_M^E) e^{-C \cdot 3072 T}]_i \quad (35)$$

$$[\Delta B_{Sm}^2]_i = [B_{Sm}^2 E - (1-f_D)\{B_{Sm}^2 E - (P_M^E)(1-e^{-0.3072 T})\}]_i \quad (36)$$

where f_D is the fraction of tubes discharged from the zone. The samarium local buckling effect can similarly be calculated now at some given time t after startup.

$$[B_{Sm}^2(t)]_i = [B_{Sm}^2 E + (\overline{pf})(B)/(\Delta P_M) - G(\Delta B_{Sm}^2 - (\overline{pf})(\Delta P_M))]_i \quad (37)$$

The change in the samarium local buckling effect from shutdown to time t after startup is then:

$$[\delta B_{Sm}^2(t)]_i = [B_{Sm}^2 @ SD - B_{Sm}^2(t)]_i \quad (38)$$

3. Neptunium /1/

Neptunium, although not a "poison" in the exact sense, must be considered since it represents a "hold-up" of Pu-239, and thus indirectly causes a reactivity transient effect. The time dependence of the decay of neptunium to plutonium can be represented by the following equation:

$$\frac{dN_p}{dt} = -\lambda_N N_p + \overline{\Sigma}_a \phi \quad (39)$$

Solving this equation, the neptunium concentration at any time t can be found:

$$N_p(t) = N_{p0} e^{-\lambda_N t} + \overline{\Sigma}_a \phi / \lambda_N (1 - e^{-\lambda_N t}) \quad (40)$$

Where $\overline{\Sigma}_a \phi / \lambda_N$ is the equilibrium concentration of neptunium. Converting concentration into local buckling values yields the following equations for the local buckling effect of neptunium at shutdown: /1/

$$[(B_{Np}^2)_K]_i = [(0.00183 f_N + 0.00122 f_E)(W)(f)]_i \quad (41)$$

$$[(B_{Np}^2)_{Pre-K}]_i = [(0.00267 f_N + 0.00184 f_E)(W)(f)]_i \quad (42)$$

The neptunium local buckling effect at time t after startup can now be written:

$$[B_{Np}^2(t)]_i = [B_{Np}^2 E + (B_{Np0}^2 - B_{Np}^2) e^{-0.2979 t}]_i \quad (43)$$

where:

$$[B_{Np_0}^2]_i = [(1-f_D)(B_{Np}^2) e^{-0.2979 T}]_i \quad (44)$$

The delta neptunium local buckling effect can now be determined as the difference between the buckling effect at shutdown and at a given time, t , after startup:

$$[\delta B_{Np}^2(t)]_i = [B_{Np}^2 @ SD - B_{Np}^2(t)]_i \quad (45)$$

4. Metal Temperature Effect

The local buckling equivalents of the metal heating effect currently in use is summarized below: /1/

$$B_H^2 = (0.00280)(W)(f) \text{ } \mu\text{b} \quad (\text{K Nat.}) \quad (46)$$

$$(0.00341)(W)(f) \text{ } \mu\text{b} \quad (\text{K Enr.}) \quad (47)$$

$$(0.00485)(W)(f) \text{ } \mu\text{b} \quad (\text{Pre-K Nat.}) \quad (48)$$

$$(0.00534)(W)(f) \text{ } \mu\text{b} \quad (\text{Pre-K Enr.}) \quad (49)$$

The buckling effect in a particular zone can be determined from the following equations:

$$[(B_H^2)_K]_i = [(0.00280 f_N + 0.00341 f_E)(W)(f)]_i \quad (50)$$

$$[(B_H^2)_{\text{Pre-K}}]_i = [(0.00485 f_N + 0.00534 f_E)(W)(f)]_i \quad (51)$$

The equations reflect the fact that the heat generation rate for enriched metal is approximately a factor of 1.22 (K Reactors) or 1.10 (Pre-K Reactors) higher than natural uranium, in the same neutron flux. The program automatically corrects the metal temperature effect in a zone for any flux distributions shifts resulting from loading changes.

5. Cold Long-Term-Gains

Changes in the basic cold pile reactivity, or "long-term-gains" mainly involve the following effects: U-235 burnout, Pu-239 buildup, Pu-240 buildup, and Pu-241 buildup. Assuming a simple polynomial fit of the form

$$B_{LTG}^2 = aE + bE^2 + cE^3 + dE^4 \text{ } \mu\text{b} \quad (52)$$

and applying a least squares analysis to reactivity data yields the following table of constants: /7/

TABLE I

	<u>K</u>		<u>Pre-K</u>	
	<u>Nat.</u>	<u>Enr.</u>	<u>Nat.</u>	<u>Enr.</u>
a	4.73×10^{-2}	9.1×10^{-3}	3.33×10^{-3}	2.0×10^{-3}
b	-5.34×10^{-5}	-1.82×10^{-5}	-4.43×10^{-5}	-1.86×10^{-5}
c	2.35×10^{-8}	7.7×10^{-9}	1.92×10^{-8}	6.3×10^{-9}
d	-3.14×10^{-12}	-1.24×10^{-12}	-3.72×10^{-12}	-1.07×10^{-12}

Local buckling effects corresponding to given pile reactivity effects may be calculated for given zone exposures (MWD/TON). Thus the buckling equivalent of "long-term-gains," B_{LTG}^2 , may be calculated, for the i th zone, from the following equation:

$$[B_{LTG}^2 @ SD] = [(B_{LTG}^2)_N(f_N) + (B_{LTG}^2)_E(f_E)]_i \quad (52)$$

The effect of an incremental exposure on the pile buckling is determined by calculating zone exposures before and after the increment, and computing the corresponding long term gains.

The exposure in a zone can be simply expressed as follows:

$$[E(t)]_i = [E^0 + E^v]_i \quad (54)$$

where E^0 is the average zone exposure at startup and E^v is the incremental exposure in the zone following startup. The following relationships have been derived to calculate time dependent exposures at the various reactors: /11/

$$K) \begin{cases} [E_N(t)]_i = [7.23(E_N @ SU) + \delta E(f/f_{cz})]_i & (55) \\ [E_E(t)]_i = [8.35(E_E @ SU) + (1.55)(\delta E)(f/f_{cz})]_i & (56) \end{cases}$$

$$old) \begin{cases} [E_N(t)]_i = [8.43(E_N @ SU) + \delta E(f/f_{cz})]_i & (57) \\ [E_E(t)]_i = [11.08(E_E @ SU) + (1.314)(\delta E)(f/f_{cz})]_i & (58) \end{cases}$$

$$C) \begin{cases} [E_N(t)]_i = [8.54(E_N @ SU) + \delta E(f/f_{cz})]_i & (59) \\ [E_E(t)]_i = [10.8(E_E @ SU) + (1.265)(\delta E)(f/f_{cz})]_i & (60) \end{cases}$$

The factor (f/f_{cz}) is a correction term included to account for average zone factor deviations from the average central region factor. This factor will be equal to unity for all zones within the central region; it will be less than unity for all zones within the E-ring or fringe regions.

At zero exposure (freshly charged fuel), the first term in the equations above will be zero, and the exposure at time t will then be:

$$[E_N]_1 = [(6E)(f/f_{CZ})]_1 [E_N]_1 = [(1.155)(6E)(f/f_{CZ})]_1 \quad K \quad (61)$$

$$[E_N]_1 = [(6E)(f/f_{CZ})]_1 [E_N]_1 = [1.314(6E)(f/f_{CZ})]_1 \quad Old \quad (62)$$

$$[E_N]_1 = [(6E)(f/f_{CZ})]_1 [E_N]_1 = [(1.265)(6E)(f/f_{CZ})]_1 \quad C \quad (63)$$

The local long-term-gains may then be expressed in terms of a local buckling effect as follows:

$$[(B_{LTG}^2(t))_N]_1 = \{(1 - f_{ND}) [a(E_N(t)) + b(E_N(t))^2 + c(E_N(t))]^3 + d(E_N(t))^4\} + f_{ND} [a(E_N(t)) + b(E_N(t))^2 + c(E_N(t))^3 + d(E_N(t))^4]_1 \quad (64)$$

$$[(B_{LTG}^2(t))_E]_1 = \{(1 - f_{ED}) [a(E_E(t)) + b(E_E(t))^2 + c(E_E(t))]^3 + d(E_E(t))^4\} + f_{ED} [a(E_E(t)) + b(E_E(t))^2 + c(E_E(t))^3 + d(E_E(t))^4]_1 \quad (65)$$

The combined buckling effect of the natural and enriched metal will be:

$$[B_{LTG}^2(t)]_1 = [(B_{LTG}^2)_N f_N + (B_{LTG}^2)_E f_E]_1 \quad (66)$$

The buckling change from shutdown to some time t is quite simply:

$$[\delta B_{LTG}^2(t)]_1 = [B_{LTG}^2(t) - B_{LTG}^2 @ SD]_1 \quad (67)$$

6.

Moderator Temperature Effect

The variation of the moderator temperature coefficient with exposure is dependent mainly on the concentration of the Pu-239 isotope in the reactor; the relationship may be written in the form: $1/8$

$$C_T = a + bn_{49} + c(n_{49})^2 \quad (68)$$

Now, n_{49} can be written as a simple function of exposure, $n_{49} = OE + PE^2$, where O and P are coefficients; therefore, C_T may be written:

$$C_T = a + b(OE + PE^2) + C(OE + PE^2)^2 \quad (69)$$

The holdup of the Pu-239 isotope in the form of neptunium must also be taken into account and we obtain the final equation:

$$C_T = a + b(OE + PE^2 - n_v) + c(OE + PE^2 - n_v)^2 \quad (70)$$

This is basically the same equation used in Reference 1 except that second order correction is made for the plutonium concentration and neptunium "hold-up" factor n_v . Evaluation of the constants yields the following: $1/8$

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TABLE II

	<u>K</u>		<u>Pre-K</u>	
	<u>Nat.</u>	<u>Enr.</u>	<u>Nat.</u>	<u>Enr.</u>
a	2.55	2.55	2.55	2.55
b	1.05×10^{-2}	1.05×10^{-2}	1.05×10^{-2}	1.05×10^{-2}
c	-2.39×10^{-6}	-2.39×10^{-6}	-2.39×10^{-6}	-2.39×10^{-6}
o	0.9963	0.839	0.9725	0.806
P	-2.28×10^{-4}	-1.469×10^{-4}	-2.50×10^{-4}	-1.594×10^{-4}

The neptunium "hold-up" term at shutdown is directly proportional to the equilibrium power level, W , and to the local flux (f_i); thus it can be determined from the following relation:

$$n_w = (d)(w)(f) \quad (71)$$

Evaluation /1/ of the constant d gives the following values for the neptunium "hold-up" at equilibrium in gms/ton.

$$n_w = (0.00733)(W)(f) \quad (\text{K Nat.}) \quad (72)$$

$$= (0.00655)(W)(f) \quad (\text{K Enr.}) \quad (73)$$

$$= (0.01274)(W)(f) \quad (\text{Pre-K Nat.}) \quad (74)$$

$$= (0.01200)(W)(f) \quad (\text{Pre-K Enr.}) \quad (75)$$

The neptunium "hold-up" after startup can be evaluated through use of the local buckling effect, due to neptunium which has been previously derived, from equation 43.

$$n_w = (3.996) B_{Np}^2(t) \quad (\text{K-Nat.}) \quad (76)$$

$$= (5.382) B_{Np}^2(t) \quad (\text{K Enr.}) \quad (77)$$

$$= (4.771) B_{Np}^2(t) \quad (\text{Pre-K Nat.}) \quad (78)$$

$$= (6.508) B_{Np}^2(t) \quad (\text{Pre-K Enr.}) \quad (79)$$

Using the appropriate constants and exposures, the moderator coefficient can be determined for natural and enriched metal before and after startup. The moderator coefficient for the i^{th} zone is determined by:

$$[C_T]_i = [(C_T)_N f_N + (C_T)_E f_E]_i \quad (80)$$

The so-called "graphite temperature coefficient" is widely used in routine hand calculations at all reactors; for any given case, this quantity, in the familiar units of cmk/MW, may be derived from Hunt N Peck output by appropriate averaging. The general technique used by the author is presented for consideration.

In general, the pile reactivity effect of graphite temperature changes may be expressed by the equation:

$$R_T = \bar{C}_T T_G \quad (81)$$

where $\bar{C}_T$ is a pile average for the $[C_T]_i$ calculated above and $\bar{T}_G$ is an "effective pile average" graphite temperature.

For convenience in hand applications, it is desirable to express this effect in terms of reactor power level:

$$R_T = \bar{C}_T (W \cdot K) \quad (82)$$

where W is the actual recorded power level, and K is a constant relating power level and "weighted" graphite temperatures. Such a relationship is valid only if the flux distribution is fairly constant during equilibrium operation.

Assuming such a relationship, the "effective pile average graphite temperature" at a given exposure may be written in the generalized form:

$$\bar{T}_G = (A)(W)(f) [1 + B(\%CO_2) + C(\%CO_2)^2] \quad (83)$$

in which the effect of reactor atmosphere is explicitly included. A method of evaluating the constants A, B, and C is described in Section F.

The moderator heating local buckling effect can now be calculated for the shutdown and startup in the i^{th} zone using the following equations:

$$[B_T^2]_i = [(T_G)(C_T)(1.869 \times 10^{-2})]_i \mu b \quad K \quad (84)$$

$$[B_T^2]_i = [(T_G)(C_T)(1.618 \times 10^{-2})]_i \mu b \text{ Pre-K} \quad (85)$$

The local buckling change from shutdown to some time t after startup can be determined by:

$$[\delta B^2(t)]_i = [B_T^2(t) - B_T^2 @ SD]_i \quad (86)$$

7. Material Bucklings

The material bucklings of a zone or region can be approximated* using the following equation:

$$[B_M^2]_i = [B_N^2 f_N + B_E^2 f_E]_i \quad (87)$$

*This approximation is good only for components with nearly equal bucklings (i.e., $B_N \approx B_E$).

The effective radial bucklings, i.e., the material buckling corrected for longitudinal leakage, of the enriched charges as a function of charge displacement and enrichment density is shown in Figure 7. A basic material buckling of 266 μb for standard length "E" columns is used in the program for K Reactors; this value should be corrected (e.g., by flux-squared weighting) for columns of different length.

8. Effective Bucklings

The local buckling effects at shutdown may be summed in each region and zone to give the total buckling effect at shutdown.

$$[B^2]_i = [B_M^2 + B_{Xe}^2 + B_{Sm}^2 + B_{Np}^2 + B_H^2 + B_{LTG}^2 + B_T^2]_i \quad (88)$$

The individual local buckling changes are similarly summed to give a total local buckling change from shutdown to some given time t :

$$[\delta B^2(t)]_i = [\delta B_{Xe}^2(t) + \delta B_{Sm}^2(t) + \delta B_{Np}^2 + \delta B_H^2 + \delta B_{LTG}^2 + \delta B_T^2]_i \quad (89)$$

The cold-to-hot buckling change in a region or zone at time t is then:

$$[\delta B_{C-H}^2(t)]_i = [\delta B^2(t) + B^2 - B_M^2]_i \quad (90)$$

9. Region and Zone Loadings

The main purpose of "spike" enrichment is the maintenance of a flat central region simultaneous with adequate reactivity for controls. Assuming that the local buckling changes (i.e., cold-to-hot-buckling, loading changes, etc.) have been calculated, and the minimum control requirement established, the enrichment requirements may be calculated for the central region and individual zones. The required material buckling is:

$$B_M^2 = B_g^2 + B_c^2 + \delta B_{C-H}^2 \quad (91)$$

where: B_g^2 = Axial geometric leakage

B_c^2 = Control buckling required for minimum control

δB_{C-H}^2 = Cold-to hot-buckling change

now,

$$B_M^2 = (N_E/N_T)B_E^2 + (N_N/N_T)B_N^2 \quad (92)$$

therefore,

$$[N_E]_i = [(N_T)(B_M^2 - B_N^2)/(B_E^2 - B_N^2)]_i \quad (93)$$

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The number of enriched columns, N_E , is calculated for the central region as well as for all zones within the region. The sum of the $[N_E]_i$ for all individual zones is then normalized to the number of enriched columns obtained for the central region, N_{CR} :

$$[N'_E]_i = (N_{CR})([N_E]_i) / \sum_{i=1}^{N1} [N_E]_i \quad (94)$$

so that,

$$\sum_{i=1}^{N1} [N'_E]_i = N_{CR} \quad (95)$$

where: $N1$ = Number of individual central zones

N_{CR} = Value obtained for central region N_E

$[N'_E]_i$ = Normalized number of "E" columns required in ith zone of central region.

The buckling in Region 3 (i.e., the fringe region) is calculated in the following manner:

$$B_3^2 = [B_M^2 + B_{Xs}^2 + B_{Sm}^2 + B_{Np}^2 + P_H^2 + B_{LTG}^2 + B_T^2 + \delta B^2(t) - B_g^2 - B_c^2] \quad (96)$$

The desired buckling in the E-Ring is then that buckling which will sustain a chain reaction while supporting a flat central region of that given size. The "zilch" or "vitabuck" programs can be applied by assuming a buckling of zero in the central region and thus establishing the enrichment buckling (B_2) required for criticality as a function of the fringe buckling (B_3). A polynomial fit of the form below can then be applied to the results,

$$B_2^2 = R + X(B_3^2) + Y(B_3^2)^2 + Z(B_3^2)^3 \quad (97)$$

where R , X , Y and Z are constants of the equation.

The remaining calculations are similar to those of the central region:

$$B_M^2 = B_2^2 + B_g^2 + P_c^2 + \delta B_{C-H}^2 \quad (98)$$

where: B_2^2 = Desired buckling in Region 2

B_g^2 = Axial geometric leakage

B_c^2 = Control bucklings applicable to Region 2

δB_{C-H}^2 = Cold-to hot-buckling

Required E-Ring bucklings (B_2) are then converted to enrichment requirements by the equation:

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$$[N_E]_i = [(N_T)(B_M^2 - P_N^2)/(B_E^2 - B_N^2)]_i, \quad (99)$$

for the E-Ring region and zones within the region. A normalization identical to the one performed for the central region is then performed.

The loading changes needed in each region and zone are then determined simply by taking the difference of the calculated enrichment requirements and the prior loading:

$$[\delta N_E]_i = [N'_E(t) - N_E @ SD]_i \quad (100)$$

This value is a major part of normal program output. A positive value is indicative that enrichment should be added and a negative value indicates that enrichment should be removed.

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C. Applications

Before the program, Hunt N Peck, can be applied to a given case, certain reactor parameters must be determined by the user to complete Hunt N Peck input. The following is a discussion of suggested methods for evaluating these parameters. The user may elect to utilize these suggested methods, or develop his own preferred techniques.

1. Moderator Temperature

Establishment of "an appropriately averaged" T_G is not a straightforward task; available graphite temperatures require considerable interpretation before such an average is achieved. One method for obtaining the constants A, B, and C, used by the author will be described; the method employs the regional buckling code CALHOT.^{/10/}

Fundamentally, CALHOT calculates the critical reactor state under the condition of zero buckling in the central "flat" zone; i.e., based upon input bucklings, the buckling effect of the graphite temperature is that uniform buckling which must be added to obtain zero buckling over the central region.

This "moderator local buckling (in μb) is part of the normal CALHOT output, and may be converted into the standard "c-mk value" through use of the appropriate conversion factor applicable to the particular reactor type. These factors are as follows:^{/17/}

Table 3

Pre-K	K
61.8 c-mk/ μb	53.5 c-mk/ μb

The moderator coefficient, C_T , must be determined, using equations 79 and 80, for the pile averaged exposures which were input to CALHOT. The "effective pile average" graphite temperature may be determined by:

$$\bar{T}_G = R_T / \bar{C}_T \quad (101)$$

and substituting into equation 83, assuming $C=0$, the following equation for the constant A is obtained.

$$A = \bar{T}_G / (W) [1.C + B(\% CO_2)] \quad (102)$$

The constant B, which corrects for changes in the thermal conductivity of the graphite with changes in the pile atmosphere, has been experimentally derived for each reactor.

Evaluation of the constant A for several different operating periods will enable obtaining a statistically weighted average. Assuming that

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the constant A applies uniformly over the entire reactor is not a valid assumption due to the coring zones at K Reactors and other variations of the graphite properties over the reactor. This assumption must be made for initial utilization of the program. Analysis of data over several operating periods should, however, enable an evaluation of the constant A applicable to each of the three main regions: central, E-ring, and fringe.

2. Horizontal Control Rods

An accurate determination of the local buckling effect due to the horizontal control rods is a difficult task. Many different methods have been used in the past with varying degrees of satisfaction. The following method is submitted as a possibility for more accurately describing the actual situation than previous methods.

The problem breaks down naturally into two separate parts, determining the local buckling effect of small individual zones and then determining the regional buckling effects.

a. Local Buckling Effect in Small Zones

In general, the individual zones are small (the user should set up zones for the particular reactor similar to those shown in Figure I), of height equal to the actual rod spacing, and centered on the rod bank.

The local buckling effect of a control rod applicable to a small zone of Figure I is simply the conventional local control strength "smeared" over the front-to-rear direction. This is accomplished as follows:

- 1) Divide the reactor into five regions in the front-to-rear plane (six at the K Reactors), corresponding to three (or four) control rods and two end sections (see Figure 10).
- 2) Calculate the equivalent uniform buckling effect for a rod or particular configuration of rods, using any of the conventional buckling codes.
3. Apply this uniform buckling reduction as a δB in the appropriate radial zones as input to Hunt N Peck.

In summary, the user must convert a control rod buckling into an equivalent radial buckling effect, and insert this as input for the primary calculation. The base case is the uncontrolled critical reactor, with a buckling in all five (or six) axial regions equal to the geometric buckling. The buckling in one or more of the longitudinal regions is reduced by the local control strength, and the uniform δB required to re-establish criticality is found.

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This δB is then the assumed radial effect of the HCR's, to be used in the appropriate Hunt N Peck zones. Corrections must be made if it extends through only a fraction of the zone. For zones within the central flat region this correction is readily apparent and is simply the fraction of the zone covered by the rod as shown by the following equation:

$$[B_C^2] = [(Local Buckling Effect) L/LZ]_i \quad 103$$

where: L = length of i th zone covered by rod

LZ_i = length of i th zone,

since the central region has a flat flux distribution. Normally, no correction is necessary for E-ring zones since control rods completely extend through these zones.

b. Local Buckling Effects in Regions

The regional local buckling effect of the horizontal control rods may be determined by any several methods; two possibilities are discussed below. The choice between these two methods probably depends on the confidence placed in current rod calibrations. Regardless of the method used, the local buckling effect of the horizontal control rods should be considered in the E-ring as well as the central region.

1) Buckling Technique

In this method the buckling effect of the rods is determined by buckling calculations in slab geometry. The local buckling effect in the front-to-rear direction, determined in the small zone analysis, is applied over the top-to-bottom direction. This gives the buckling effect of the rod when it is completely inserted across the reactor from near-to-far. A rod calibration curve can then be determined by performing buckling calculations in the near-to-far direction by varying the distance over which the local buckling effect of the rod applies.

The sum of the pile reactivity effects of the control rods is then determined for each of the two regions. For the central region the reactivity effect is the reactivity from its normal control position to the edge of the E-ring as shown in Figure 2. The remainder of the rod worth up to the full-out position may be assigned to the E-ring with little sacrifice of accuracy. The summation of the reactivity effects from the rods in each of the two regions can then be converted to a region buckling using curves similar to Figures 6 and 7. These curves were plotted for KE Reactor assuming an initial flat central zone, changing the buckling in one of the regions and finding the equivalent uniform buckling effect over the pile.

2) Rod Calibration Technique

The present rod calibration tables may be used to establish zone rod worths if desired. These are used in the following manner:

- a) Determine the reactivity effect over the pile of a given rod from the inserted position up to the edge of the E-ring; the remainder of the reactivity up to the full-out position may be assigned to the E-ring region.
- b) Sum the reactivity effects of the two regions for all rods used and convert reactivities to regional bucklings using curves for the reactor similar to Figures 6 and 7.

3. Nonuranium-Columns, Splines, PCCF

The local buckling effect of nonuranium columns in small zones should be determined as follows:

- a. Establish the size of individual zones, all containing approximately an equal number of tubes. Zone sizes will then be used to establish equivalent "supercell" radii to be used in cylindrical buckling calculations. The radius for an equivalent "supercell" is found to be: $11/$

$$r = 10.7477 \sqrt{N_T} \quad (K) \quad (104)$$

$$r = 12.002 \sqrt{N_T} \quad (\text{Pre-K}) \quad (105)$$

where N_T is the number of tubes in the "supercell."

- b. Perform a cylindrical buckling calculation as follows:

- 1) Set up a conventional reactor problem, with a central region of one lattice unit (the "test cell") surrounded by N_T-1 tubes of "supercell," and the standard reactor regions (e.g., flat zone, enrichment ring, buckled zone).
- 2) Using ZILCH or some other standard code, calculate the uniform buckling which must be applied over the central two regions ("test" and "supercells") to produce criticality with identical material in regions 1 and 2 (i.e., test cell contents same as supercell contents); call this reduction δB_1 .
- 3) Calculate the uniform buckling as in step 2), except that the lattice buckling equivalent for the nonuranium column under study is substituted in the test cell (Region 1); call this uniform reduction δB_2 .

- 4) The regional buckling effect of the non-uranium column is then the difference in buckling reductions:

$$\Delta B = \delta B_2 - \delta B_1$$

This ΔB is the correction for the presence of a non-uranium column in the center of a region and should be algebraically included in Hunt N Peck input. Lattice material buckling equivalents for many common materials are listed in the table below (the reader is referred to Reference 1, pp. 117-121, for materials not listed):

Material	Lattice Buckling	
	Pre-K	K
E-metal	255	255
C-metal	-	555
Air	-60	0
Water	-458	-480
Graphite	-129	-45
Bismuth	-180	-120
Solid Aluminum	-300	-274
Tubular Aluminum	-360	-368
Perforated Aluminum	-390	-382
Boll	-2572	-2160
Lead Cadmium	-2572	-2160
Thorium	-1440	-1350
Solid Natural Uranium	0	0
I&E Natural Uranium	-8	?
Depleted Uranium	-675	-660
Cadmium Spline	-450	-420
Boron Carbide Spline	-390	-360

4. Water Mixers

The local buckling effect of water mixers can be obtained from Reference 9 for natural and enriched columns; the buckling effect may then be obtained from the following relation:

$$[B_{Mx}^2]_i = [B_{N-Mix}^2 f_N + B_{E-Mix}^2 f_E]_i \quad (108)$$

5. Region and Zone Control Bucklings

The region and zone local control bucklings (required input to the program), may be determined simply by summing all local control buckling effects in every zone and region. For the i th zone this may be written as:

$$[B_c^2]_i = [B_{HCR}^2 + B_{NU}^2 + B_{Mx}^2]_i \quad (109)$$

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where: B_{HCR}^2 = local buckling effect of the control rods
(Section 2 above)

B_{NU}^2 = local buckling effect of nonuranium columns
(Section 3)

B_{Mix}^2 = local buckling effect of water mixers
(Section 4)

D. Input Preparation

All additional input data for the execution of the program is readily available from the Production Scheduling Operation. This data appears on the regional Z list* which is issued on a routine basis to pre-establish scheduled and unscheduled outage discharge sequences.

The required input is summarized in the following table.

*Discussed in HW-46100, Pile Physics Manual of Standard Practices

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<u>CARD</u>	<u>NAME OF PROGRAM VARIABLE</u>	<u>FORMAT</u>	<u>EXAMPLE</u>	<u>DESCRIPTION</u>
1,2,3	V	12F6.2	XXX.XX or <u>+</u> XX.XX	Control buckling in zone; i.e. rods, splines, PCCF, etc.
4	NCODE	I2	XX or <u>+</u> X	Reactor code (Old = -1, C = 0, K = 0)
	A	F7.4	XX.XXXX or <u>+</u> X.XXXX	Graphite temperature coefficients
	B	F7.4	XX.XXXX or <u>+</u> X.XXXX	" " "
	C	F7.4	XX.XXXX or <u>+</u> X.XXXX	" " "
	R	F6.2	XXX.XX or <u>+</u> XX.XX	Buckling constant
	X	E11.4	XXX.XXXXE+X or <u>+</u> XX.XXXXE+X	Buckling constant
	Y	E11.4	XXX.XXXXE+X or <u>+</u> XX.XXXXE+X	Buckling constant
	Z	E11.4	XXX.XXXXE+X or <u>+</u> XX.XXXXE+X	Buckling constant
	EB1	F5.1	XXX.X or <u>+</u> XX.X	Material buckling of E ² in Region 1
	EB2	F5.1	XXX.X or <u>+</u> XX.X	Material buckling in E ² in Region 2
5	ICASE	I3	XXX or <u>+</u> XX	Case number
	P	F5.2	XX.XX or <u>+</u> X.XX	Power level (MW x 10 ⁻²)
	T	F6.3	XX.XXX or <u>+</u> X.XXX	Estimated outage length (days)
	XEP	F6.1	XXXX.X or <u>+</u> XXX.X	Exposure increment (MWD/T)
	HE1	F5.2	XX.XX or <u>+</u> X.XX	Helium percentage @ SD
	HE2	F5.2	XX.XX or <u>+</u> X.XX	Helium percentage @ SD
	XNT	F5.0	XXXX. or <u>+</u> XXX.	Number of pile active tubes
	N1	I3	XXX or <u>+</u> XX	Number of central zones
	N2	I3	XXX or <u>+</u> XX	Number of E-ring zones
	N3	I3	XXX or <u>+</u> XX	Number of fringe zones

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<u>CARD</u>	<u>NAME OF PROGRAM VARIABLE</u>	<u>FORMAT</u>	<u>EXAMPLE</u>	<u>DESCRIPTION</u>
6 to NR* +5	ZONE	I3	XXX or <u>+</u> XX	Zone number
	F	F5.3	X.XXX or <u>+</u> .XXX	Average zone factor
	FE	F5.3	X.XXX or <u>+</u> .XXX	Desired average zone factor
	XN	F5.0	XXXX. or <u>+</u> XXX.	Number of natural columns
	SDN	F7.0	XXXXXX. or <u>+</u> XXXXXX.	Natural residual @ SD
	EN	F7.0	XXXXXX. or <u>+</u> XXXXXX.	Natural residual @ SU
	XNAT	F5.0	XXXX. or <u>+</u> XXX.	Number of natural columns discharged
	XE	F5.0	XXXX. or <u>+</u> XXX.	Number of enriched columns discharged
	SDE	F7.0	XXXXXX. or <u>+</u> XXXXXX.	Enriched residual @ SD
	EE	F7.0	XXXXXX. or <u>+</u> XXXXXX.	Enriched residual @ SU
	XENR	F5.0	XXXX. or <u>+</u> XXX.	Number of enriched columns discharged

*NR is the total number of small zones plus the three regions; i.e., central, E-ring and fringe.

$$NR = N1 + N2 + N3 + 3$$

The arrangement of the data cards is extremely important for successful use of the program. The region data card should always precede the data cards for the zones within that region. For example, Card 6 should contain data for the central region, and the succeeding N1 data cards should contain data for all zones within the central region. Consult the following table for the correct card sequence.

Table 4

<u>Card</u>	<u>Type of Data</u>
1,2,3	Control bucklings
4	Pile parameters
5	Pile parameters
6	Central region
7 to N1 + 6	Central zones
N1 + 7	E-ring region
N1 + 8 to N1 + N2 + 7	E-ring zones
N1 + N2 + 8	Fringe region
N1 + N2 + 9 to NR + 5	Fringe zones

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It is not necessary to perform a calculation for every zone in the reactor unless the data is specifically required; e.g., calculations for the zones within the fringe region generally are not necessary. To eliminate the calculation of zone data within a region simply insert "0" as the input for N1, N2 or N3. Calculations on the region data only can be accomplished by setting all three equal to "0". For any given region, data must be included for every zone within that region or no zone at all; data on Cards 1-3 should, of course, be in correct order corresponding to the sequence of region and zone data cards.

If more than one case is desired Card 5 of the $i + 1$ st case should follow immediately after the last zone data card in the i th case. A blank card may be inserted after the final card in the data deck. Since the data on Cards 1-4 will nearly always remain the same, over a given set of calculations, these cards are read into the computer only on the first case. The following "80-80" form illustrates the proper placement of input data.

E. Output Discussion

The output of the program is printed on five separate sheets. The following is the total information that is available:

- Output Sheet 1. Input data to the program; e.g., power level, estimated outage length, helium percentages, number of pile active tubes, and number of zones within each region. The effective buckling of each of the three regions is also part of the output.
- Output Sheet 2. Additional data; e.g., number of natural and enriched tubes in each region and zone, and their respective shutdown and startup exposures in MWD/T.
- Output Sheet 3. The region and zone local buckling data at shutdown for each of the separate reactivity effects; xenon, samarium, neptunium, metal temperature, long-term-gains, graphite temperature, material and total local buckling effects.
- Output Sheet 4. The local buckling change from shutdown to some given input exposure increment, specified in input, "XEP"; following startup for each separate reactivity effect.
- Output Sheet 5. The input control bucklings; these are printed out along with the number of enrichment columns needed (to maintain a flat central zone with adequate reactivity for control) and the change in the enrichment inventory, from the shutdown status, for each zone. A sample of the output for a K-Reactor calculation is shown on the next several pages.

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INPUT DATA

P# 40.00	NCODE# 0
T# 21.00	A# 0.0640
HE1# 95.00	B# 0.0106
HE2# 80.00	C# 0.
XNT# 3212.	R# 0.1560E 03
N1# 24	X# -0.8379E 00
N2# 8	Y# -0.1605E-02
N3# -0	Z# -0.2688E-05

BUCKLING IN CENTRAL REGION #	0.0
BUCKLING IN E-RING REGION #	149.56
BUCKLING IN FRINGE REGION #	7.55

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ZONE	NATURAL	SHUTDOWN NATURAL EXPOSURE	STARTUP NATURAL EXPOSURE	SPIN	SHUTDOWN SPIKE EXPOSURE	STARTUP SPIKE EXPOSURE
1	1690	79.36	41.29	108	92.23	16.70
11	63	75.00	25.70	14	85.43	19.57
12	72	73.82	32.35	7	97.00	2.66
13	63	78.19	-0.	17	85.47	-0.
14	72	77.82	-0.	8	91.00	-0.
15	69	73.13	71.19	9	84.22	37.00
21	73	69.95	31.33	7	82.86	29.86
22	71	58.46	32.31	8	77.00	50.50
23	74	77.43	-0.	6	92.00	-0.
24	76	78.39	-0.	5	90.40	0.
25	72	70.69	69.36	7	124.00	48.00
31	70	72.64	59.90	7	70.86	20.29
32	74	74.69	62.20	8	79.00	34.25
33	64	91.11	46.53	13	102.92	-0.
34	77	88.39	42.86	7	105.29	-0.
35	69	91.80	39.33	1	19.00	19.00
41	61	74.20	60.67	8	99.38	46.88
42	61	70.69	58.15	9	91.89	22.78
43	65	88.69	42.06	5	87.80	4.40
44	63	90.27	39.13	7	105.29	-0.
45	66	87.88	43.73	3	108.00	-0.
51	79	74.42	69.42	9	94.78	12.67
52	87	75.08	73.97	12	91.50	23.17
53	71	91.77	40.94	5	108.20	-0.
54	78	91.77	43.50	6	103.50	15.33
2	86	81.90	28.67	317	92.36	32.65
61	10	58.00	22.50	37	79.32	43.35
62	13	84.31	9.23	34	78.06	44.94
63	19	76.16	54.68	27	90.81	63.67
64	6	75.17	-0.	40	96.22	45.72
65	9	90.22	-0.	37	104.92	-0.
66	7	93.29	-0.	39	90.21	-0.
67	9	100.67	32.22	52	106.21	29.94
68	13	84.46	60.92	51	87.55	41.45
3	932	72.61	37.80	-0	0.	0.

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ZONE BUCKLING DATA AT SHUTDOWN IN MICROBUCKS

ZONE	XENDN	SAMARIUM	NEPTUNIUM	METAL	LONG-TERM GAINS	GRAPHITE	MATERIAL	TOTAL
1	51.21	10.05	8.29	11.94	12.22	40.35	73.33	44.41
11	51.07	10.08	7.98	11.99	10.93	38.53	90.83	59.16
12	51.32	10.04	8.45	12.04	12.08	39.75	70.87	40.84
13	50.94	10.10	7.78	11.92	10.65	38.51	97.40	65.82
14	51.10	10.05	8.17	11.84	12.16	39.40	73.31	43.71
15	51.00	10.05	8.02	11.77	11.75	37.63	76.60	45.13
21	50.89	10.04	7.94	11.59	11.94	36.20	70.63	38.33
22	50.94	10.05	7.98	11.68	11.64	36.02	73.58	40.65
23	50.88	10.03	7.95	11.55	12.40	38.06	67.96	38.09
24	51.04	10.03	8.17	11.69	12.74	39.12	65.12	36.04
25	50.82	10.04	7.86	11.52	11.72	36.79	70.87	39.16
31	51.26	10.04	8.38	11.98	12.11	38.54	71.36	40.35
32	51.15	10.04	8.22	11.88	12.10	38.60	72.79	42.20
33	51.51	10.08	8.55	12.43	11.49	45.23	88.05	62.20
34	51.34	10.04	8.49	12.05	12.73	43.45	69.74	44.00
35	51.06	10.01	8.26	11.59	13.94	41.95	54.96	29.94
41	51.19	10.05	8.24	11.97	11.69	39.30	75.72	46.26
42	51.04	10.06	8.04	11.83	11.37	37.50	79.43	47.33
43	51.17	10.03	8.30	11.84	13.00	42.12	67.19	40.99
44	51.23	10.05	8.33	11.98	12.52	43.23	73.31	47.48
45	51.14	10.02	8.32	11.75	13.33	42.04	61.21	35.35
51	51.23	10.05	8.32	11.98	11.93	39.42	73.80	43.56
52	51.20	10.06	8.24	11.99	11.72	39.34	72.85	47.44
53	51.42	10.03	8.63	12.09	13.08	44.73	65.99	41.63
54	51.32	10.03	8.49	12.00	13.02	44.02	67.19	42.39
2	51.70	10.37	6.86	13.32	2.38	40.71	220.31	181.15
61	51.14	10.37	6.29	12.61	2.60	34.01	220.45	176.66
62	51.38	10.34	6.63	12.77	3.92	36.53	206.78	166.11
63	50.79	10.27	6.28	11.77	5.21	34.76	177.57	138.43
64	50.69	10.41	5.78	12.24	0.92	35.76	238.07	195.64
65	51.74	10.38	6.86	13.40	1.51	43.51	224.11	186.76
66	51.82	10.40	6.88	13.61	1.66	41.49	233.42	193.88
67	51.67	10.40	6.71	13.43	0.71	43.75	233.41	196.67
68	51.38	10.37	6.51	12.93	2.49	38.09	222.51	181.90
3	49.33	10.00	4.74	7.73	13.28	21.86	51.90	15.25

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DELTA BUCKLING CHANGE IN ZONE AFTER 100 NWD/TON EXPOSURE

ZONE	DELTA XENON	DELTA SAMARIUM	DELTA NEPTUNIUM	DELTA METAL	DELTA LONG TERM GAINS	DELTA GRAPHITE	TOTAL
1	0.14	2.50	0.60	0.14	-4.50	-3.71	-4.83
11	-0.01	2.77	0.41	-0.01	-5.10	-7.18	-9.12
12	0.25	2.44	0.75	0.26	-4.72	-6.13	-7.15
13	-0.15	4.46	0.26	-0.16	-7.15	-17.48	-20.22
14	0.04	4.38	0.48	0.04	-8.28	-18.29	-21.64
15	-0.07	1.11	0.35	-0.07	0.55	7.89	9.76
21	-0.18	2.38	0.23	-0.19	-4.61	-2.28	-4.64
22	-0.12	2.18	0.29	-0.13	-4.23	-1.07	-3.08
23	-0.19	4.36	0.22	-0.19	-8.53	-16.93	-21.25
24	-0.02	4.35	0.42	-0.02	-8.72	-17.98	-21.97
25	-0.25	1.19	0.15	-0.26	0.84	8.91	10.57
31	0.20	1.43	0.67	0.20	0.95	3.77	5.32
32	0.08	1.46	0.53	0.08	-0.97	4.73	5.90
33	0.43	2.91	0.96	0.46	-4.48	-8.99	-8.71
34	0.28	2.80	0.77	0.29	-5.39	-6.71	-7.97
35	0.	2.84	0.44	-0.	-6.73	-5.08	-8.53
41	0.12	1.46	0.58	0.12	-0.81	3.92	5.39
42	-0.04	1.58	0.39	-0.04	-0.74	3.91	5.06
43	0.10	2.80	0.56	0.11	-5.75	-5.29	-7.47
44	0.17	3.01	0.64	0.17	-5.82	-7.96	-9.79
45	0.08	2.57	0.54	0.09	-5.29	-4.32	-6.33
51	0.17	1.28	0.64	0.17	0.15	4.89	7.29
52	0.13	1.17	0.58	0.13	0.61	6.16	8.78
53	0.36	2.81	0.89	0.37	-5.82	-8.30	-9.69
54	0.26	2.71	0.76	0.27	-5.51	-6.42	-7.94
2	0.08	3.20	0.45	0.10	-0.21	-8.71	-5.09
61	-0.49	2.33	-0.12	-0.61	-0.37	0.27	1.02
62	-0.23	2.79	0.13	-0.29	-2.04	-3.74	-3.38
63	-0.81	1.93	-0.42	-0.96	-0.64	6.35	5.45
64	-0.95	3.14	-0.51	-1.17	0.36	-1.54	-0.66
65	0.11	5.01	0.48	0.14	-0.07	-23.69	-18.01
66	0.19	5.05	0.56	0.25	-0.37	-21.69	-16.01
67	0.04	3.66	0.40	0.05	1.02	-12.34	-7.17
68	-0.24	2.44	0.11	-0.31	0.54	-1.64	0.90
3	-0.63	2.07	-0.12	-0.51	4.82	-0.01	-4.03

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FLATTENING CHANGES BY ZONE

ZONE	CONTROL BUCKLINGS	ENRICHMENT NEEDED	ENRICHMENT CHANGE
1	21.53	132.4	-55.6
11	36.27	13.0	-1.0
12	14.17	4.0	-3.0
13	40.89	19.3	2.3
14	15.32	9.7	1.7
15	24.71	2.2	-6.8
21	14.39	4.1	-2.9
22	16.55	4.5	-3.5
23	10.29	7.8	1.8
24	7.49	6.8	1.8
25	20.76	0.6	-6.4
31	21.55	2.5	-4.5
32	19.54	1.5	-6.5
33	41.67	12.7	-0.3
34	22.66	6.2	-0.8
35	12.15	1.8	0.8
41	21.96	2.2	-5.8
42	25.44	3.9	-5.1
43	27.78	6.8	1.8
44	30.42	8.3	1.3
45	17.77	3.1	0.1
51	20.74	1.4	-7.6
52	19.21	0.3	-11.7
53	24.19	6.3	1.3
54	15.77	3.2	-2.8
2	9.61	307.2	-9.8
61	-0.	34.0	-3.0
62	-0.	34.3	0.3
63	-0.	31.3	4.3
64	-0.	33.3	-6.7
65	-0.	36.0	-1.0
66	-0.	36.1	-2.9
67	20.67	50.7	-1.3
68	20.67	51.6	0.6
3	0.	0.	0.
	132.4	134.8	307.2
			302.0

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F. Example Calculation

The following examples illustrate application of the previously described techniques in solving selected problems at the KE Reactor; the techniques are intended as suggestions to aid the user in optimizing flattening at other reactors, to be utilized at his option:

1. Horizontal Control Rods

Generally, loading changes are tailored to assure sufficient control at the reactivity minimum ("the samarium dip"), thus, a rod pattern designed for adequate control flexibility with minimum poisoning is selected as the basis for calculations. In this example the rod configuration shown in Figure 2 was selected; pile reactivity effects were determined from values given in Figure 3 by performing buckling calculations in the near-to-far direction using techniques as stated previously.

Central Region

<u>Rod Position</u>	<u>Pile Reactivity</u>
1 @ 65%, 2 @ 25%	116.6 c-mk
19 @ 25%, 20 @ 65%	119.3 "
15 @ 70%, 18 @ 20%	31.4 "
7 @ 65%, 10 @ 20%	34.7 "
3 @ 20%, 6 @ 70%	33.5 "
11 @ 20%, 14 @ 65%	35.8 "
	<u>371.3 c-mk</u>

This central zone configuration is equivalent to 371 c-mk; using Figure 6 a pile reactivity of 371 c-mk is found to give a local buckling effect of 9.4 μ b in the central region.

E-Ring Region

<u>Rod Position</u>	<u>Pile Reactivity</u>
1&2 @ 80%	36.4 c-mk
19&20 @ 80%	36.4 "
7 @ 80%	5.9 "
15 @ 80%	5.9 "
6 @ 80%	5.2 "
14 @ 80%	5.2 "
	<u>95.0 c-mk</u>

The control rods extending into the E-ring are equivalent to a pile reactivity of 95 c-mk, or a local buckling effect of 12.1 μ b in the E-ring region (Figure 7).

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The effective HCR local control bucklings in the zones is a function of the percentage of the zone covered by the rod. For example, in zone 31, #6 rod is at 70 per cent; total zone length is 18 per cent (62%-80%). The control rod buckling is then (using Table 2):

$$\delta B_C^2 = \frac{(70-80)}{(62-80)} (6.47) = 3.59 \text{ } \mu\text{b}$$

This procedure is similarly performed for all zones.

2. Nonuranium Loadings

In the typical central region loading at the KE Reactor, there are five graphite stringers and five air channels, in addition to 16 splines necessary for adequate control following startup. The local buckling effect of these charges may be calculated as follows using Table 1 and Figure 4.

<u>Material</u>	<u>Local Buckling Effect</u>	<u>Total Buckling Effect</u>
Splines	-0.744 μb	-16(0.744) = -11.90
A.C.	-0.115 μb	-5(0.115) = -0.58
G.S.	-0.207 μb	-5(0.207) = -1.04
		-13.52 μb

The local buckling effect of nonuranium columns in the individual zones is calculated in a similar manner. For example, zone 31 has 77 tubes; a spline in this zone has a local buckling effect of 18.4 μb (Figure 3).

3. Region and Zone Control Bucklings

The local buckling effects for the region and zones can now be determined by applying equation 109.

$$\begin{aligned} B_C^2 (\text{Region 1}) &= 9.4 \text{ } \mu\text{b} (\text{control rods}) + 13.5 \text{ } \mu\text{b} (\text{nonuranium}) \\ &\quad + 2.5 \text{ } \mu\text{b} (\text{water-mixers})^{12} \\ &= 25.4 \text{ } \mu\text{b} \end{aligned}$$

$$\begin{aligned} B_C^2 (\text{Region 2}) &= 12.1 \text{ } \mu\text{b} (\text{control rods}) + 2.5 \text{ } \mu\text{b} (\text{water-mixers}) \\ &= 14.6 \text{ } \mu\text{b} \end{aligned}$$

$$B_C^2 (\text{Region 3}) = 2.5 \text{ } \mu\text{b} (\text{water-mixers})$$

$$\begin{aligned} B_C^2 (\text{Zone 31}) &= 3.59 \text{ } \mu\text{b} (\text{control rod}) + 18.4 \text{ } \mu\text{b} (1 \text{ spline}) \\ &\quad + 2.5 \text{ } \mu\text{b} (\text{water-mixers}) \\ &= 24.49 \text{ } \mu\text{b} \end{aligned}$$

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IV. APPENDIX

The following pages contain tabulated information for applying this program to the various reactors, plus graphical presentations of reactivity variables at the KE Reactor (for illustrative purposes).

A. Tabulated Reactivity Parameters

Table 1

Nominal Reactivities and Lattice Material Bucklings of Various Materials

(References 4 and 5)

Material	Nominal Reactivity (c-mk)		Lattice Buckling μb	
	B,C,D,DR,F,H	KE,KW	B,C,D,DR,F,H	KE,KW
Air	-12.2	-3.3	-67	-10
Water	-45.5	-27.2	-462	-470
Graphite	-17.5	-6.0	-125	-60
Bismuth	-22.3	-9.5	-180	-130
Solid Aluminum	-32.5	-17.9	-300	-295
Tubular Aluminum	-37.5	-22.2	-362	-375
Perforated Aluminum	-40.0	-22.7	-392	-385
Splines B ₄ C	-40.0	-22.0	-392	-370

Table 2

Listing of Horizontal Control Rod Worths

(Reference 6)

Reactor	Rod Worth (Single Centered)	Local Control Strength
B,D,DR,F,H	4.7 μb	59.5 μb
C	5.4 μb	72.5 μb
K	3.4 μb	59.0 μb

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Table 3

Flux Distribution Correction Factors For Rod Worth Calculations

(Reference 6)

Reactor	Rod Bank	$\frac{\int_{\text{rod}} \phi^2 dx}{\int_{\text{center rod}} \phi^2 dx}$	Remarks
B,C,D,DR,F,H	Upstream	0.51	Assumes rod system displaced 14" upstream
	Center	0.98	
	Downstream	0.77	
KE,KW	Inboard	0.94	
	Outboard	0.57	

Table 4

Local Buckling Effect of Control Rods for Small Zones in Front Face Plane at KE Reactor

(Reference 11)

Rod Bank	Local Buckling for Small Zones	Remarks
Front Inboard	13.71 μb	Assumes initial cosine flux distribution and rod system displaced 4" upstream.
Front Outboard	6.47 μb	
Rear Inboard	14.46 μb	
Rear Outboard	7.25 μb	
Both Inboard	31.34 μb	

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Table 5

Listing of Horizontal Control
Rod Worths at KE Reactor

(Reference 11)

Rod Bank	Rod Worth	Remarks
Front Inboard	2.170 μ b	Assumes cosine flux distribution (front-to-rear) and rod system displaced 4" up- stream.
Front Outboard	0.958 μ b	
Rear Inboard	2.304 μ b	
Rear Outboard	1.081 μ b	

B. Graphical Presentation of KE Reactivity Variables

Figure 1

KE Reactor Zone Locations

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Figure 2

KE Reactor Control Rod Positions

Figure 3

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Local Buckling Effect in Zone
Due to Centrally Located Material

Figure 4

Local Buckling Effect in Central Region Due to Centrally Located Material

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Figure 5
HCR Strength vs. Position

Figure 6

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KE - Delta Buckling in Central Region vs.
Pile Reactivity Effect

Figure 7

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KE - Delta Buckling in E-Ring vs.
Pile Reactivity Effect

Figure 8

Lattice Material Buckling
vs.
Nominal Reactivity

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Figure 9
Enrichment Buckling
vs.
Charge Displacement and Enrichment Density

*Density of Enrichment in
a particular region
 $[e]_i = \left[\frac{NE}{n} \right]$

A PROGRAM TO PERFORM ZONE FLATTENING IN REACTOR

*** INPUT ***

CARDS 1 V - INPUT ZONE CONTROL BUCKLINGS
2 AND 3

CARD 4 NCODE - REACTOR CODE %OLD#-1,C#0,K#0

A - GRAPHITE TEMPERATURE CONSTANT

B - GRAPHITE TEMPERATURE CONSTANT

C - GRAPHITE TEMPERATURE CONSTANT

R - BUCKLING CONSTANT

X - BUCKLING CONSTANT

Y - BUCKLING CONSTANT

Z - BUCKLING CONSTANT

EB1 -- MATERIAL BUCKLING OF ENRICHMENT IN CENTRAL ZONE

EB2 -- MATERIAL BUCKLING OF ENRICHMENT IN E-RING ZONE

CARD 5 ICASE - CASE NUMBER

P - POWER

T - ESTIMATED OUTAGE LENGTH

XEP - DELTA EXPOSURE INCREMENT

HE1 - SHUTDOWN HELIUM

HE2 - STARTUP HELIUM

XNT - TOTAL NUMBER OF PILE ACTIVE TUBES

N1 - NUMBER OF CENTRAL ZONES

N2 - NUMBER OF E-RING ZONES

N3 - NUMBER OF FRINGE ZONES

CARDS 6 ZONE - ZONE NUMBER

TO NR&5 F - AVERAGE ZONE FACTOR

FE - DESIRED ZONE FACTOR

XN - NUMBER OF NATURAL COLUMNS IN ZONE

SDN - SHUTDOWN NATURAL RESIDUAL

EN - STARTUP NATURAL RESIDUAL

XNAT - NUMBER OF NATURAL COLUMNS BEING DISCHARGED

XE - NUMBER OF ENRICHED COLUMNS IN ZONE

SDE - SHUTDOWN ENRICHED RESIDUAL

EE - STARTUP ENRICHED RESIDUAL

XENR - NUMBER OF ENRICHED COLUMNS BEING DISCHARGED

MAIN PROGRAM

*** FORMAT STATEMENTS

1 FORMAT %I3,F5.2,F6.3,F6.1,F5.2,F5.2,F5.0,I3,I3,I3

0030
0050
0060
0061
0062
0063
0063
0064
0065
0066
0067
0068
0069
0070

0065
0070
0071
0080
0100
0110
0111
0120
0130
0131
0132
0131
0140
0150
0151
0160
0170
0180
0190
0200
0210
0220
0230
0231
0240
0250
0260

C. Source Program Listing

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**** K-HUNT N PECK ****

2	FORMAT %I3,F5.3,F5.3,F5.0,F7.0,F7.0,F5.0,F5.0,F7.0,F7.0,F5.0	0270
3	FORMAT %I1H139X,8HSHUTDOWN,8X,7HSTARTUP,22X,8HSHUTDOWN,8X,7HSTA	0280
	IRUP	0290
4	FORMAT %I1H 40X,7HNATURAL,8X,7HNATURAL,23X,5HSPIKE,11X,5HSPIKE	0300
5	FORMAT %I1H 12X4HZONE,8X,7HNATURAL,8X,8HEXPOSURE,8X,8HEXPOSURE,	0310
1	8X,5HSPIKE,8X,8HEXPOSURE,8X,8HEXPOSURE	0320
6	FORMAT %I1H 13X,I2,10X,I4,11X,F6.2,10X,F6.2,9X,I4,10X,F6.2,10X,	0330
1	F6.2	
7	FORMAT %I1H137X,45HZONE BUCKLING DATA AT SHUTDOWN IN MICROBUCKS	0350
1		0360
8	FORMAT %I1H07X,4HZONE,5X,5HXENON,5X,8HSAMARIUM,5X,9HNEPTUNIUM,5	0370
1	X,5HMETAL,5X,15HLONG-TERM-GAINS,5X,8HGRAPHITE,5X,8HMATERIAL,5X	0380
1	,5HTOTAL	0390
9	FORMAT %I1H 8X,I2,5X,F6.2,6X,F6.2,7X,F6.2,6X,F6.2,9X,F6.2,11X,F	0400
1	6.2,7X,F6.2,5X,F6.2	0410
10	FORMAT %I1H133X,56HDELTA BUCKLING CHANGE IN ZONE AFTER MWD/	0420
	ITON EXPOSURE	0430
11	FORMAT %I1H&69X,I3	0440
12	FORMAT %I1H020X,5HDELTA,7X,5HDELTA,10X,5HDELTA,8X,5HDELTA,11X,5	0450
1	HDELTA,12X,5HDELTA	0460
13	FORMAT %I1H 10X,4HZONE,6X,5HXENON,6X,8HSAMARIUM,6X,9HNEPTUNIUM,	0470
1	6X,5HMETAL,6X,15HLONG-TERM-GAINS,6X,8HGRAPHITE,6X,5HTOTAL	0480
14	FORMAT %I1H 11X,I2,6X,F6.2,7X,F6.2,8X,F6.2,7X,F6.2,10X,F6.2,12X	0490
1	,F6.2,6X,F6.2	0500
15	FORMAT %I1H147X,26HFLATTENING CHANGES BY ZONE	0510
16	FORMAT %I1H046X,7HCONTROL,6X,10HENRICHMENT,5X,10HENRICHMENT	0520
17	FORMAT %I1H 36X,4HZONE,5X,9HBUCKLINGS,7X,6HNEEDED,9X,6HCHANGE	0530
18	FORMAT %I1H 37X,I2,7X,F6.2,10X,F5.1,10X,F5.1	
44	FORMAT %I2F6.2	
55	FORMAT %I2,3F7.4,F6.2,3E11.4,2F5.1	
77	FORMAT %I1H044X,F5.1,4X,F5.1,4X,F5.1,4X,F5.1	0542
120	FORMAT %I1H112X,39HICASE WAS FOUND TO BE ZERO SO I STOPPED	0543
121	FORMAT %I1H08X,61HHUNT N PECK - A PROGRAM TO PERFORM ZONE FLATT	0544
	ENING IN REACTOR	0545
130	FORMAT %I1H155X,11HHUNT N PECK	
131	FORMAT %I1H055X,10HINPUT DATA	
132	FORMAT %I1H045X,3HP# F5.2,12X,7HNCODE# I2	
133	FORMAT %I1H 45X,3HT# F6.2,11X,3HA# F8.4	
134	FORMAT %I1H 45X,5HHE1# F5.2,10X,3HB# F8.4	
135	FORMAT %I1H 45X,5HHE2# F5.2,10X,3HC# F8.4	
136	FORMAT %I1H 45X,5HXNT# F5.0,10X,3HR# E12.4	
137	FORMAT %I1H 45X,4HN1# I2,14X,3HX# E12.4	
138	FORMAT %I1H 45X,4HN2# I2,14X,3HY# E12.4	
139	FORMAT %I1H 45X,4HN3# I2,14X,3HZ# E12.4	

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140 FORMAT %1H042X,36HBUCKLING IN CENTRAL REGION # 0.0 □
141 FORMAT %1H 42X,27HBUCKLING IN E-RING REGION #F9.2□
142 FORMAT %1H 42X,27HBUCKLING IN FRINGE REGION #F9.2□
C *** DIMENSION STATEMENT
 DIMENSION KONE%40□,F%40□,BM%40□,XN%40□,SDN%40□,EN%40□,XE%40□,SDE%4
10□,EE%40□,XNAT%40□,XENR%40□,XA%40□,SUMFAC%40□,FM%40□,WSTR%40□,BXE%
240□,WSTR2%40□,BXE2%40□,BSM%40□,RSM0%40□,PM0%40□,RSM%40□,DPM%40□,DR
3SM%40□,PF%40□,E%40□,ALPH%40□,D%40□,S%40□,XUMSPL%40□,G%40□,H%40□,BS
4M2%40□,DBSM%40□,BNP%40□,RNPO%40□,RNP%40□,RNE%40□,RNT%40□,DBNP%40□,
5CM0%40□,CM%40□,BMET%40□,CM02%40□,CM2%40□,DBMET%40□,RLTGE%40□,RLTGN
6%40□,BLTG%40□,ENAT%40□,EENR%40□,FND%40□,FED%40□,DRLTGN%40□,DRLTGE%
740□,DBLTG%40□,O%40□,P%40□,XWN%40□,CTN%40□,CTE%40□,CT%40□,TG%40□,BG
8%40□,ENAT2%40□,EENR2%40□,O2%40□,P2%40□,XWN2%40□,CTN2%40□,CTE2%40□,
9CT2%40□,TG2%40□,DBXE%40□,EED%40□,EXD%40□,KN%40□,KE%40□
 DIMENSION DBG%40□,BT%40□,DBUCK%40□,XUMENR%40□,FD%40□,ENRCZ%40□,V%3
16□,FE%40□,PNX%40□,PEX%40□,TN%40□,TX%40□,TIN%40□,TIX%40□,DEL%40□
 WRITE OUTPUT TAPE 3,121
 READ INPUT TAPE 2,44, V
 READ INPUT TAPE 2,55,NCODE,A,B,C,R,X,Y,Z,EB1,EB2
70 READ INPUT TAPE 2,1,ICASE,PE,T,XEP,HE1,HE2,XNT,N1,N2,N3
 IF %ICASE□ 71,81,71
71 W # 100.0*PE
 NR # N1 & N2 & N3 & 3
 J1#N1&1
 J2#N1&2
 J3#N1&N2&2
 J4#N1&N2&3
 J5#N1&3
 J6#NR-N2-N3-2
 J7#NR-N3-1
 I # 1
 GO TO 90
80 I # I & 1
90 READ INPUT TAPE 2,2,KONE%I□,F%I□,FE%I□,XN%I□,SDN%I□,EN%I□,XNAT
1 %I□,XE%I□,SDE%I□,EE%I□,XENR%I□
 XA%I□ # XN%I□ & XE%I□
 SUMFAC%I□ # F%I□*XA%I□
 IF %I-1□ 21,22,21
22 DX # XNT/%W*FE%I□*7.23□
 SX # XEP*DX
 HX # EXPF%-0.3072*SX□
 HA # FE%I□
C *** XENON CALCULATIONS
21 FM%I□ # XN%I□/XA%I□ & 1.0206*XE%I□/XA%I□

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	IF %I-J6 101,101,102	0742
101	WSTR%I # 0.72*FM%I*W*F%I	0743
	BM%I # 51.9*%I/%I & EB1*%I/%I	0743
	GO TO 23	0744
102	IF %I-J7 104,104,105	0745
104	WSTR%I # 0.80*FM%I*W*F%I	0746
	BM%I # 51.9*%I/%I & EB2*%I/%I	0746
	GO TO 23	0747
105	WSTR%I # 1.0*FM%I*W*F%I	0748
	BM%I # 51.9*%I/%I & EB2*%I/%I	0749
23	BXE%I # 0.11657*WSTR%I/%I & 1.976E-3*WSTR%I	0761
	IF %I-J6 106,106,107	0762
106	WSTR2%I # 0.72*FM%I*W*FE%I	0763
	GO TO 25	0764
107	IF %I-J7 109,109,110	0765
109	WSTR2%I # 0.80*FM%I*W*FE%I	0766
	GO TO 25	0767
110	WSTR2%I # 1.0*FM%I*W*FE%I	0768
25	BXE2%I # 0.11657*WSTR2%I/%I & 1.976E-3*WSTR2%I	0781
	DBXE%I # BXE%I - BXE2%I	
C	*** SAMARIUM CALCULATIONS	
	BSM%I # 9.999*%I/%I & 10.467*%I/%I	0823
	FD%I # %XNAT%I & XENR%I/%I	0824
	RSMO%I # %I. - FD%I*BSM%I*53.5	0825
	PMO%I # %I. - FD%I*W*F%I*0.0836	0826
	RSM%I # RSMO%I & PMO%I*%I. - EXPF%-0.3072*T	0827
	DPM%I # 0.0836*W*FE%I - PMO%I*EXPF%-0.3072*T	0828
	DRSM%I # BSM%I*53.5 - RSM%I	0829
	E%I # 7.23*%I/%I & 8.35*%I/%I	0831
	ALPH%I # 4.915E-11*%I/%I & 5.495E-11*%I/%I	0832
	PF%I # 0.3072/%I.3072-5.7024E-12*W*FE%I/%I*%I*ALPH%I	0833
	G%I # EXPF%-5.7024E-12*W*FE%I*SX/%I*%I*ALPH%I	0835
	BSM2%I # BSM%I*53.5 & PF%I*HX*DPM%I - G%I*%I*DRSM%I & PF	0838
1	%I*DPM%I	0839
	DBSM%I # BSM%I - 1.869E-2*BSM2%I	0840
C	*** NEPTUNIUM CALCULATIONS	
32	BNP%I # %I.0981*%I/%I & 0.079*%I/%I*1.869E-2*W*F	1040
1	%I	1041
	RNPO%I # %I. - FD%I*BNP%I*53.5	1043
	RNP%I # RNPO%I*EXPF%-0.2979*T	1043
	RNE%I # %I.0981*%I/%I & 0.079*%I/%I*W*FE%I	1044
	RNT%I # RNE%I & %RNP%I - RNE%I*EXPF%-0.2979*SX	1045
	DBNP%I # BNP%I - 1.869E-2*RNT%I	1046
C	*** METAL EFFECT CALCULATIONS	

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34	CMO%I# 0.191 - 1.2E-5*W*F%I#	1101
	CM%I# CMO%I* $XN\%I/XA\%I$ & 1.215*CMO%I* $XE\%I/XA\%I$	1102
	BMET%I# CM%I*1.869E-2*W*F%I#	1103
	CMO2%I# 0.191 - 1.2E-5*W*FE%I#	1104
	CM2%I# CMO2%I* $XN\%I/XA\%I$ & 1.215*CMO2%I* $XE\%I/XA\%I$	1105
	DBMET%I# BMET%I - 1.869E-2*CM2%I*W*FE%I#	1106
C	*** EXPOSURE CALCULATION	
	TIN%I# SDN%I/ $XN\%I$	1107
	TN%I# EN%I/ $XN\%I$	1108
	TIX%I# SDE%I/ $XE\%I$	1109
	TX%I# EE%I/ $XE\%I$	1110
	EED%I# 8.35*TIX%I	1125
	EXD%I# 7.23*TIN%I	1126
C	*** LONG-TERM-GAINS CALCULATIONS	1609
40	RLTGE%I# 9.1E-3*EED%I - 1.82E-5*EED%I**2 & 7.7E-9*EED%I**3	1610
1	3 - 1.24E-12*EED%I**4	1620
	RLTGN%I# 4.73E-2*EXD%I - 5.34E-5*EXD%I**2 & 2.35E-8*EXD%I	1630
1	**3 - 3.14E-12*EXD%I**4	1640
	BLTG%I# RLTGN%I* $XN\%I/XA\%I$ & RLTGE%I* $XE\%I/XA\%I$	1650
	PNX%I# XEP*FE%I/HA	1658
	PEX%I# 1.155*XEP*FE%I/HA	1659
	ENAT%I# 7.23*TN%I & PNX%I	1660
	EENR%I# 8.35*TX%I & PEX%I	1670
	FND%I# XNAT%I/ $XN\%I$	1680
	FED%I# XENR%I/ $XE\%I$	1690
	DRLTGN%I# %1. - FND%I**%4.73E-2*ENAT%I - 5.34E-5*ENAT%I**3	1700
1	2 & 2.35E-8*ENAT%I**3 - 3.14E-12*ENAT%I**4 & FND%I**%4.73E-	1710
2	2*PNX%I - 5.34E-5*PNX%I**2 & 2.35E-8*PNX%I**3 - 3.14E-12*PN	1720
3	X%I**4 - RLTGN%I	1730
	DRLTGE%I# %1. - FED%I**%9.1E-3*EENR%I - 1.82E-5*EENR%I**2	1740
1	& 7.7E-9*EENR%I**3 - 1.24E-12*EENR%I**4 & FED%I**%9.1E-3*	1750
2	PEX%I - 1.82E-5*PEX%I**2 & 7.7E-9*PEX%I**3 - 1.24E-12*PEX%I	1760
3	**4 - RLTGE%I	1770
	DBLTG%I# DRLTGN%I* $XN\%I/XA\%I$ & DRLTGE%I* $XE\%I/XA\%I$	1780
C	*** MODERATOR EFFECT CALCULATIONS	1799
	O%I# 0.9963*EXD%I - 2.28E-4*EXD%I**2	1800
	P%I# 0.8390*EED%I - 1.469E-4*EED%I**2	1810
	CTN%I# %2.55 & 1.05E-2*%O%I-0.00733*W*F%I# - 2.39E-6*%O%I	1830
1	-0.00733*W*F%I#**2** $XN\%I/XA\%I$	1840
	CTE%I# %2.55 & 1.05E-2*%P%I-0.00796*W*F%I# - 2.39E-6*%P%I	1850
1	-0.00796*W*F%I#**2** $XE\%I/XA\%I$	1860
	CT%I# CTN%I & CTE%I	1870
	TG%I# A*W*F%I**%1.0 & B*%100.0-HEI# & C*%100.0-HEI**2	1880
	BG%I# TG%I*CT%I*1.869E-2	1890

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02810 # 0.9963*ENAT810 - 2.28E-4*ENAT810**2
P2810 # 0.806*EENR810 - 1.469E-4*EENR810**2
CTN2810 # 22.55 & 1.05E-2*202810-0.0747*RN810 - 2.39E-6*202
810-0.0747*RN810**2**XN810/XA810
CTE2810 # 22.55 & 1.05E-2*202810-0.1006*RN810 - 2.39E-6*202
810-0.1006*RN810**2**XE810/XA810
CT2810 # CTN2810 & CTE2810
TG2810 # A*W*FE810**21.0 & B*2100.0-HE20 & C*2100.0-HE20**20
DBG810 # TG2810*CT2810**1.869E-2 - BG810
*** SUMMATION OF BUCKLINGS AND FLATTENING CHANGES IN ZONE
BT810 # BM810 - BXE810 - BSM810 - BNP810 - BME810 & BLTG810 &
BG810
DBUCK810 # DBXE810 & DBSM810 & DBNP810 & DBME810 & DBLTG810 &
DBG810
IF 2NR - I 100,100,80
WRITE OUTPUT TAPE 3,130
WRITE OUTPUT TAPE 3,131
WRITE OUTPUT TAPE 3,132,PE,NCODE
WRITE OUTPUT TAPE 3,133,I,A
WRITE OUTPUT TAPE 3,134,HE1,B
WRITE OUTPUT TAPE 3,135,HE2,C
WRITE OUTPUT TAPE 3,136,XNI,R
WRITE OUTPUT TAPE 3,137,N1,X
WRITE OUTPUT TAPE 3,138,N2,Y
WRITE OUTPUT TAPE 3,139,N3,Z
DO 56 I#1,J1
ENRCZ810 # XA810*28M810-BT810-DBUCK810&V810-40.180/2EB1-51.90
IF 21-10 56,42,56
CZE # ENRCZ810
XUMENR810 # ENRCZ810
CONTINUE
IF 2N10 65,65,66
SUM # 0.0
DO 58 I#2,J1
SUM # SUM & ENRCZ810
DO 59 I#2,J1
XUMENR810 # CZE*ENRCZ810/SUM
SUME # 0.0
DO 60 I#2,J1
SUME # SUME & XUMENR810
B3 # BT8J40 - DBUCK8J40 - V2J40 - 11.72
DB # R & X*83 & Y*83**2 & Z*83**3
DO 57 I#J2,J3
ENRCZ810 # XA810*28M810-BT810-DBUCK810&V810&DB-40.180/2EB2-51.

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190	IF 81-J2 57,61,57	2087
61	EZE # ENRCZ810	2088
57	XUMENR810 # ENRCZ810	2089
68	CONTINUE	2090
62	IF 2N2 67,67,68	2091
63	SUMX # 0.0	2092
64	DO 62 I#J5,J3	2093
67	SUMX # SUMX & ENRCZ810	2094
69	DO 63 I#J5,J3	2095
	XUMENR810 # EZE*ENRCZ810/SUMX	2096
	SUMY # 0.0	2097
	DO 64 I#J5,J3	2098
	SUMY # SUMY & XUMENR810	2100
	DO 69 I#1,NR	
	DEL810 # XUMENR810 - XE810	
	WRITE OUTPUT TAPE 3,140	
	WRITE OUTPUT TAPE 3,141,DB	
	WRITE OUTPUT TAPE 3,142,B3	
	WRITE OUTPUT TAPE 3,3	
	WRITE OUTPUT TAPE 3,4	
	WRITE OUTPUT TAPE 3,5	
	DO 75 I#1,NR	2102
	KN810 # XN810	2103
75	KE810 # XE810	2104
	WRITE OUTPUT TAPE 3,6,8KONE810,KN810,TIN810,KN810,KE810,IX810	2105
	,IX810, I#1,NR	2106
	WRITE OUTPUT TAPE 3,7	2110
	WRITE OUTPUT TAPE 3,8	2120
	WRITE OUTPUT TAPE 3,9,8KONE810,BXE810,BSM810,BNP810,BMET810,BL	2130
	TG810,BG810,BM810,BT810, I#1,NR	2140
	WRITE OUTPUT TAPE 3,10	2150
	IEXP # XEP	2160
	WRITE OUTPUT TAPE 3,11,IEXP	2170
	WRITE OUTPUT TAPE 3,12	2179
	WRITE OUTPUT TAPE 3,13	2180
	WRITE OUTPUT TAPE 3,14,8KONE810,DBXE810,DBSM810,DBNP810,DBMET8	2190
	10,DBLTG810,DBG810,DBUCK810, I#1,NR	2200
	WRITE OUTPUT TAPE 3,15	2210
	WRITE OUTPUT TAPE 3,16	2220
	WRITE OUTPUT TAPE 3,18,8KONE810,V810,XUMENR810,DEL810, I#1,NR	2230
	WRITE OUTPUT TAPE 3,77,SUM,SUMY,SUMX	2240
	GO TO 70	2251
	WRITE OUTPUT TAPE 3,120	2253
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CALL EXIT

ENDZ1,1,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0

STORAGE NOT USED BY PROGRAM

DEC OCT
5725 13135

DEC OCT
32561 77461

STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

DEC OCT	DEC OCT	DEC OCT	DEC OCT
ALPH 4684 11114	BG 3204 06204	BLTG 3804 07334	BMET 4044 07714
BVP 4364 10414	BSM2 4444 10534	BSM 5004 11614	BT 2564 05004
BXE 5124 12014	CM2 3964 07574	CMO2 4004 07644	CMO 4124 10034
CT2 2884 05504	CTE2 2924 05554	CTE 3324 06374	CTN2 2964 05624
CT 3784 06324	DBG 2604 05054	DBLTG 3524 06704	DBMET 3924 07524
DBSM 4404 10464	DBUCK 2524 04734	DBXE 2804 05364	DEL 2048 04000
DRLTG 3564 06754	DRLTGN 3604 07024	DRSM 4804 11304	D 4644 11044
EENR2 3124 06064	EENR 3724 07214	EE 5404 12434	ENAT2 3164 06134
ENR2 2404 04544	EN 5524 12624	E 4724 11164	EXD 2724 05244
FED 3644 07074	FE 2328 04430	FM 5204 12124	FND 3684 07144
G 4524 10654	H 4484 10604	KE 2644 05124	KN 2684 05174
D2 3084 06014	O 3484 06614	P2 3044 05744	PIX 2248 04310
PND 4724 11474	PNX 2288 04360	P 3444 06564	RLTG 3884 07454
RNF 4244 10224	RNPD 4324 10344	RNP 4284 10274	RNT 4204 10154
RSM 4884 11414	SDE 5444 12504	SDN 5564 12674	S 4604 10774
TG2 2844 05414	TG 3244 06254	TIN 2128 04120	FIX 2088 04050
IX 2168 04170	V 2364 04474	WSTR2 5084 11734	WSTR 5164 12054
XENR 5324 12314	XE 5484 12554	XNAT 5364 12364	XN 5604 12744
XUMSPL 4564 10724	XWN2 3004 05674	XWN 3404 06514	

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

DEC OCT	DEC OCT	DEC OCT	DEC OCT
A 2008 03710	B3 2007 03727	B 2006 03726	C 2005 03725
DB 2003 03723	DX 2002 03722	EB1 2001 03721	EB2 2000 03720
HA 1998 03716	HE1 1997 03715	HE2 1996 03714	HX 1995 03713
IEXP 1993 03711	I 1992 03710	J1 1991 03707	J2 1990 03706
J4 1988 03704	J5 1987 03703	J6 1986 03702	J7 1985 03701
N2 1983 03677	N3 1982 03676	NCODE 1981 03675	NR 1980 03674
R 1978 03672	SUME 1977 03671	SUM 1976 03670	SUMX 1975 03667
SX 1973 03665	T 1972 03664	W 1971 03663	XEP 1970 03662
X 1968 03660	Y 1967 03657	Z 1966 03656	

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SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

EFN	LOC	EFN	LOC	EFN	LOC	EFN	LOC	EFN	LOC
801	1 03433	802	2 03623	803	3 03611	804	4 03576	805	5 03564
806	6 03542	807	7 03526	808	8 03513	809	9 03463	80A	10 03445
80B	11 03430	80C	12 03425	80D	13 03407	80E	14 03362	80F	15 03345
80G	16 03335	80H	17 03323	80I	18 03311	80IC	44 03302	80IN	55 03277
802D	77 03271	803D	120 03262	803P	121 03250	8042	130 03233	8043	131 03226
8044	132 03221	8045	133 03212	8046	134 03203	8047	135 03174	8048	136 03165
8049	137 03156	804A	138 03147	804B	139 03140	804C	140 03131	804D	141 03120
804E	142 03110								

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
10	1948 03634	20	1542 03006	30	1546 03012	40	32767 77777	60	1595 03073
C0G0	1964 03654	C0G1	1965 03655	D0401	48 00060	E03	118 00166	E05	165 00245
E08	217 00331	E0D	276 00424	E0T	1182 02236	E012	1241 02331		

LOCATIONS OF NAMES IN TRANSFER VECTOR

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
EXIT	7 00007	EXP	6 00006	%FIL0	2 00002	%FPT0	0 00000	%RTN0	5 00005
%SLI0	4 00004	%STH0	1 00001	%TSH0	3 00003				

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXIT	EXP	%FIL0	%FPT0	%RTN0	%SLI0	%STH0	%TSH0
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EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
70	45	00061	71	48	00117	80	59	00170	90	60	00174	22	65	00247
21	69	00273	101	71	00310	102	74	00333	104	75	00337	105	78	00360
23	80	00400	106	82	00414	107	84	00426	109	85	00432	110	87	00442
25	88	00451	32	103	00667	34	109	00771	40	121	01075	100	150	01764
42	171	02165	56	173	02171	66	175	02200	58	177	02205	59	179	02215
60	182	02230	65	183	02237	61	188	02316	57	190	02322	68	192	02332
62	194	02337	63	196	02347	64	199	02362	67	200	02367	69	201	02372
75	212	02465	81	246	02766									

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00000	%FPT	BCD 1	%FPT	00053	STR	00127	50A	CLA N1
00001	%STH	BCD 1	%STH	00054	STQ EB1	00130		ADD 2
00002	%FIL	BCD 1	%FIL	00055	STR	00131		STO J1
00003	%TSH	BCD 1	%TSH	00056	STQ EB2	00132	51A	CLA N1
00004	%SLI	BCD 1	%SLI	00057	TSX %RTN,4	00133		ADD 2
00005	%RTN	BCD 1	%RTN	00060	D 401 LXD C 1,4	00134		STO J2
00006	EXP	BCD 1	EXP	00061	45A CAL 2	00135	52A	CLA N1
00007	EXIT	BCD 1	EXIT	00062	SXD 6,4	00136		ADD N2
00010	\$\$	CLA 2		00063	TSX %TSH,4	00137		ADD 2
00011		STO 6		00064	PZE 8	00140		STO J3
00012		CLA %FPT		00065	LXD 6,4	00141	53A	CLA N1
00013		STO 8		00066	46A STR	00142		ADD N2
00014		STZ 4-205		00067	STQ ICASE	00143		ADD 2
00015	40A	CAL 2		00070	STR	00144		STO J4
00016		TSX %STH,4		00071	STQ PE	00145		LXD J4,4
00017		PZE 8		00072	STR	00146	54A	CLA N1
00020		TSX %FIL,4		00073	STQ T	00147		ADD 2
00021	41A	CAL 2		00074	STR	00150		STO J5
00022		TSX %TSH,4		00075	STQ XEP	00151	55A	CLA NR
00023		PZE 8		00076	STR	00152		SUB N2
	42A	BSS		00077	STQ HE1	00153		SUB N3
00024		TSX %SLI,4		00100	STR	00154		SUB 2
00025		PZE V		00101	STQ HE2	00155		STO J6
00026		PZE 36		00102	STR	00156	56A	CLA NR
00027		TSX %RTN,4		00103	STQ XNT	00157		SUB N3
00030	43A	CAL 2		00104	STR	00160		SUB 2
00031		TSX %TSH,4		00105	STQ N1	00161		STO J7
00032		PZE 8		00106	STR	00162	57A	CLA 2
00033	44A	STR		00107	STQ N2	00163		STO I
00034		STQ NCODE		00110	STR	00164		LXD I,1
00035		STR		00111	STQ N3	00165	58A	TRA 60A
00036		STQ A		00112	SXD 6,4	00166	E 3	SXD C 1,4
00037		STR		00113	TSX %RTN,4	00167		SXD C 0,1
00040		STQ B		00114	LXD 6,4	00170	59A	CLA I
00041		STR		00115	47A CLA ICASE	00171		ADD 2
00042		STQ C		00116	47A1 TZE 246A	00172		STO I
00043		STR		00117	48A LDQ 3	00173		LXD I,1
00044		STQ R		00120	FMP PE	00174	60A	CAL 2
00045		STR		00121	STO W	00175		SXD 6,4
00046		STQ X		00122	49A CLA N1	00176		TSX %TSH,4
00047		STR		00123	ADD N2	00177		PZE 8
00050		STQ Y		00124	ADD N3	00200		LXD 6,4
00051		STR		00125	ADD 2	00201	61A	STR
00052		STQ Z		00126	STO NR	00202		STQ KONE 1,1

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00203	STR	00257	66A	LDQ	XEP	00333	74A	CLA	I	
00204	STQ	F&1,1	00260	FMP	DX	00334		SUB	J7	
00205	STR		00261	STO	SX	00335	74A1	TZE	75A	
00206	STQ	FE&1,1	00262	67A	LDQ	3&E2	00336		TPL	78A
00207	STR		00263	FMP	SX	00337	75A	LDQ	F&1,1	
00210	STQ	XN&1,1	00264	CHS		00340		FMP	3&E6	
00211	STR		00265	SXD	6&E4,4	00341		XCA		
00212	STQ	SDN&1,1	00266	TSX	EXP,4	00342		FMP	FM&1,1	
00213	STR		00267	LXD	6&E4,4	00343		XCA		
00214	STQ	EN&1,1	00270	STO	HX	00344		FMP	W	
00215	STR		00271	68A	CLA	FE&1,1	00345		STO	WSTR&1,1
00216	STQ	XNAT&1,1	00272		STO	HA	00346	76A	CLA	EB2
00217	STR		00273	69A	CLA	3&E3	00347		FDP	XA&1,1
00220	STQ	XE&1,1	00274		FDP	XA&1,1	00350		FMP	XE&1,1
00221	STR		00275		FMP	XE&1,1	00351		STO	1&E1
00222	STQ	SDE&1,1	00276		STO	1&E1	00352		CLA	3&E5
00223	STR		00277		CLA	XN&1,1	00353		FDP	XA&1,1
00224	STQ	EE&1,1	00300		FDP	XA&1,1	00354		FMP	XN&1,1
00225	STR		00301		XCA		00355		FAD	1&E1
00226	STQ	XENR&1,1	00302		FAD	1&E1	00356		STO	BM&1,1
00227	SXD	6&E4,4	00303		STO	FM&1,1	00357	77A	TRA	80A
00230	TSX	8RTN,4	00304	70A	CLA	I	00360	78A	LDQ	F&1,1
00231	LXD	6&E4,4	00305		SUB	J6	00361		FMP	3&E7
00232	62A	CLA	XN&1,1	00306	70A1	TZE	71A		XCA	
00233		FAD	XE&1,1	00307		TPL	E&8		FMP	FM&1,1
00234		STO	XA&1,1	00310	71A	LDQ	F&1,1		XCA	
00235	63A	LDQ	F&1,1	00311		FMP	3&E4		FMP	W
00236		FMP	XA&1,1	00312		XCA			STO	WSTR&1,1
00237		STO	SUMFAC&1,1	00313		FMP	FM&1,1		CLA	EB2
00240	64A	CLA	I	00314		XCA			FDP	XA&1,1
00241		SUB	2&E2	00315		FMP	W		FMP	XE&1,1
00242	64A1	TZE	E&5	00316		STO	WSTR&1,1		STO	1&E1
00243		TPL	69A	00317	72A	CLA	EB1		CLA	3&E5
00244		TRA	69A	00320		FDP	XA&1,1		FDP	XA&1,1
00245	E&5	SXD	C&G1,4	00321		FMP	XE&1,1		FMP	XN&1,1
00246		SXD	C&G0,1	00322		STO	1&E1		FAD	1&E1
00247	65A	LDQ	3&E1	00323		CLA	3&E5		STO	BM&1,1
00250		FMP	W	00324		FDP	XA&1,1		LDQ	3&E9
00251		XCA		00325		FMP	XN&1,1		FMP	WSTR&1,1
00252		FMP	FE&1,1	00326		FAD	1&E1		FAD	3&E7
00253		STO	1&E1	00327		STO	BM&1,1		STO	1&E1
00254		CLA	XNT	00330	73A	TRA	80A		CLA	3&E8
00255		FDP	1&E1	00331	E&8	SXD	C&G1,4		FDP	1&E1
00256		STQ	DX	00332		SXD	C&G0,1		FMP	WSTR&1,1

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00407	STO BXE&1,1	00463	STO DBXE&1,1	00537	STO RSM&1,1
00410 81A	CLA I	00464 90A	CLA 3&11	00540 95A	LDQ 3&2
00411	SUB J6	00465	FDP XA&1,1	00541	FMP T
00412 81A1	TZE 82A	00466	FMP XE&1,1	00542	CHS
00413	TPL E&D	00467	STO 1&1	00543	SXD 6&4,4
00414 82A	LDQ FE&1,1	00470	CLA 3&10	00544	TSX EXP,4
00415	FMP 3&4	00471	FDP XA&1,1	00545	LXD 6&4,4
00416	XCA	00472	FMP XN&1,1	00546	STO 1&1
00417	FMP FM&1,1	00473	FAD 1&1	00547	LDQ PMO&1,1
00420	XCA	00474	STO BSM&1,1	00550	FMP 1&1
00421	FMP W	00475 91A	CLA XNAT&1,1	00551	STO 1&2
00422	STO WSTR2&1,1	00476	FAD XENR&1,1	00552	LDQ FE&1,1
00423 83A	TRA 88A	00477	FDP XA&1,1	00553	FMP 3&13
00424 E&D	SXD C&G1,4	00500	STQ FD&1,1	00554	XCA
00425	SXD C&G0,1	00501 92A	CLA 3&7	00555	FMP W
00426 84A	CLA I	00502	FSB FD&1,1	00556	FSB 1&2
00427	SUB J7	00503	STO 1&1	00557	STO DPM&1,1
00430 84A1	TZE 85A	00504	LDQ 3&12	00560 96A	LDQ BSM&1,1
00431	TPL 87A	00505	FMP 1&1	00561	FMP 3&12
00432 85A	LDQ FE&1,1	00506	XCA	00562	FSB RSM&1,1
00433	FMP 3&6	00507	FMP BSM&1,1	00563	STO DRSM&1,1
00434	XCA	00510	STO RSMO&1,1	00564 97A	CLA 3&14
00435	FMP FM&1,1	00511 93A	CLA 3&7	00565	FDP XA&1,1
00436	XCA	00512	FSB FD&1,1	00566	FMP XE&1,1
00437	FMP W	00513	STO 1&1	00567	STO 1&1
00440	STO WSTR2&1,1	00514	LDQ 3&13	00570	CLA 3&1
00441 86A	TRA 88A	00515	FMP 1&1	00571	FDP XA&1,1
00442 87A	LDQ FE&1,1	00516	XCA	00572	FMP XN&1,1
00443	FMP 3&7	00517	FMP W	00573	FAD 1&1
00444	XCA	00520	XCA	00574	STO E&1,1
00445	FMP FM&1,1	00521	FMP F&1,1	00575 98A	CLA 3&16
00446	XCA	00522	STO PMO&1,1	00576	FDP XA&1,1
00447	FMP W	00523 94A	LDQ 3&2	00577	FMP XE&1,1
00450	STO WSTR2&1,1	00524	FMP T	00600	STO 1&1
00451 88A	LDQ 3&9	00525	CHS	00601	CLA 3&15
00452	FMP WSTR2&1,1	00526	SXD 6&4,4	00602	FDP XA&1,1
00453	FAD 3&7	00527	TSX EXP,4	00603	FMP XN&1,1
00454	STO 1&1	00530	LXD 6&4,4	00604	FAD 1&1
00455	CLA 3&8	00531	CHS	00605	STO ALPH&1,1
00456	FDP 1&1	00532	FAD 3&7	00606 99A	LDQ XNT
00457	FMP WSTR2&1,1	00533	STO 1&1	00607	FMP ALPH&1,1
00460	STO BXE2&1,1	00534	LDQ PMO&1,1	00610	STO 1&1
00461 89A	CLA BXE&1,1	00535	FMP 1&1	00611	LDQ W
00462	FSB BXE2&1,1	00536	FAD RSMO&1,1	00612	FMP 3&17

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00613 FDP 10E1
 00614 FMP FE1,1
 00615 CHS
 00616 FAD 30E2
 00617 STO 10E2
 00620 CLA 30E2
 00621 FDP 10E2
 00622 STQ PF1,1
 00623 100A LDQ XNT
 00624 FMP ALPH1,1
 00625 STO 10E1
 00626 LDQ W
 00627 FMP 30E17
 00630 FDP 10E1
 00631 FMP FE1,1
 00632 XCA
 00633 FMP SX
 00634 CHS
 00635 SXD 60E4,4
 00636 TSX EXP,4
 00637 LXD 60E4,4
 00640 STO G1,1
 00641 101A LDQ PF1,1
 00642 FMP DPM1,1
 00643 FAD DRSM1,1
 00644 STO 10E1
 00645 LDQ G1,1
 00646 FMP 10E1
 00647 STO 10E2
 00650 LDQ DPM1,1
 00651 FMP PF1,1
 00652 XCA
 00653 FMP HX
 00654 STO 10E3
 00655 LDQ BSM1,1
 00656 FMP 30E12
 00657 FAD 10E3
 00660 FSB 10E2
 00661 STO BSM21,1
 00662 102A LDQ 30E18
 00663 FMP BSM21,1
 00664 CHS
 00665 FAD BSM1,1
 00666 STO DBSM1,1

00667 103A CLA 30E20
 00670 FDP XA1,1
 00671 FMP XE1,1
 00672 STO 10E1
 00673 CLA 30E19
 00674 FDP XA1,1
 00675 FMP XN1,1
 00676 FAD 10E1
 00677 STO 10E2
 00700 LDQ F1,1
 00701 FMP 10E2
 00702 XCA
 00703 FMP 30E18
 00704 XCA
 00705 FMP W
 00706 STO BNP1,1
 00707 104A CLA 30E7
 00710 FSB FD1,1
 00711 STO 10E1
 00712 LDQ 30E12
 00713 FMP 10E1
 00714 XCA
 00715 FMP BNP1,1
 00716 STO RNPO1,1
 00717 105A LDQ 30E21
 00720 FMP T
 00721 CHS
 00722 SXD 60E4,4
 00723 TSX EXP,4
 00724 LXD 60E4,4
 00725 STO 10E1
 00726 LDQ RNPO1,1
 00727 FMP 10E1
 00730 STO RNP1,1
 00731 106A CLA 30E20
 00732 FDP XA1,1
 00733 FMP XE1,1
 00734 STO 10E1
 00735 CLA 30E19
 00736 FDP XA1,1
 00737 FMP XN1,1
 00740 FAD 10E1
 00741 STO 10E2
 00742 LDQ FE1,1

00743 FMP 10E2
 00744 XCA
 00745 FMP W
 00746 STO RNE1,1
 00747 107A LDQ 30E21
 00750 FMP SX
 00751 CHS
 00752 SXD 60E4,4
 00753 TSX EXP,4
 00754 LXD 60E4,4
 00755 STO 10E1
 00756 CLA RNP1,1
 00757 FSB RNE1,1
 00760 XCA
 00761 FMP 10E1
 00762 FAD RNE1,1
 00763 STO RNT1,1
 00764 108A LDQ 30E18
 00765 FMP RNT1,1
 00766 CHS
 00767 FAD BNP1,1
 00770 STO DBNP1,1
 00771 109A LDQ F1,1
 00772 FMP 30E23
 00773 XCA
 00774 FMP W
 00775 CHS
 00776 FAD 30E22
 00777 STO CMO1,1
 01000 110A LDQ CMO1,1
 01001 FMP 30E24
 01002 FDP XA1,1
 01003 FMP XE1,1
 01004 STO 10E1
 01005 CLA CMO1,1
 01006 FDP XA1,1
 01007 FMP XN1,1
 01010 FAD 10E1
 01011 STO CM1,1
 01012 111A LDQ F1,1
 01013 FMP CM1,1
 01014 XCA
 01015 FMP 30E18
 01016 XCA

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01017 FMP W
 01020 STO BMET&1,1
 01021 112A LDQ FE&1,1
 01022 FMP 3&23
 01023 XCA
 01024 FMP W
 01025 CHS
 01026 FAD 3&22
 01027 STO CM02&1,1
 01030 113A LDQ CM02&1,1
 01031 FMP 3&24
 01032 FDP XA&1,1
 01033 FMP XE&1,1
 01034 STO 1&1
 01035 CLA CM02&1,1
 01036 FDP XA&1,1
 01037 FMP XN&1,1
 01040 FAD 1&1
 01041 STO CM2&1,1
 01042 114A LDQ FE&1,1
 01043 FMP 3&18
 01044 XCA
 01045 FMP CM2&1,1
 01046 XCA
 01047 FMP W
 01050 CHS
 01051 FAD BMET&1,1
 01052 STO DBMET&1,1
 01053 115A CLA SDN&1,1
 01054 FDP XN&1,1
 01055 STQ TIN&1,1
 01056 116A CLA EN&1,1
 01057 FDP XN&1,1
 01060 STQ TN&1,1
 01061 117A CLA SDE&1,1
 01062 FDP XE&1,1
 01063 STQ TIX&1,1
 01064 118A CLA EE&1,1
 01065 FDP XE&1,1
 01066 STQ TX&1,1
 01067 119A LDQ 3&14
 01070 FMP TIX&1,1
 01071 STO EED&1,1
 01072 120A LDQ 3&1

01073 FMP TIN&1,1
 01074 STO EXD&1,1
 01075 121A LDQ EED&1,1
 01076 FMP EED&1,1
 01077 XCA
 01100 FMP EED&1,1
 01101 XCA
 01102 FMP EED&1,1
 01103 STO 1&1
 01104 LDQ 3&28
 01105 FMP 1&1
 01106 STO 1&2
 01107 LDQ EED&1,1
 01110 FMP EED&1,1
 01111 XCA
 01112 FMP EED&1,1
 01113 STO 1&3
 01114 LDQ 3&27
 01115 FMP 1&3
 01116 STO 1&4
 01117 LDQ EED&1,1
 01120 FMP EED&1,1
 01121 STO 1&5
 01122 LDQ 3&26
 01123 FMP 1&5
 01124 STO 1&6
 01125 LDQ 3&25
 01126 FMP EED&1,1
 01127 FSB 1&6
 01130 FAD 1&4
 01131 FSB 1&2
 01132 STO RLTGE&1,1
 01133 122A LDQ EXD&1,1
 01134 FMP EXD&1,1
 01135 XCA
 01136 FMP EXD&1,1
 01137 XCA
 01140 FMP EXD&1,1
 01141 STO 1&1
 01142 LDQ 3&32
 01143 FMP 1&1
 01144 STO 1&2
 01145 LDQ EXD&1,1
 01146 FMP EXD&1,1

01147 XCA
 01150 FMP EXD&1,1
 01151 STO 1&3
 01152 LDQ 3&31
 01153 FMP 1&3
 01154 STO 1&4
 01155 LDQ EXD&1,1
 01156 FMP EXD&1,1
 01157 STO 1&5
 01160 LDQ 3&30
 01161 FMP 1&5
 01162 STO 1&6
 01163 LDQ 3&29
 01164 FMP EXD&1,1
 01165 FSB 1&6
 01166 FAD 1&4
 01167 FSB 1&2
 01170 STO RLTGN&1,1
 01171 123A CLA RLTGE&1,1
 01172 FDP XA&1,1
 01173 FMP XE&1,1
 01174 STO 1&1
 01175 CLA RLTGN&1,1
 01176 FDP XA&1,1
 01177 FMP XN&1,1
 01200 FAD 1&1
 01201 STO BLTG&1,1
 01202 124A CLA XEP
 01203 FDP HA
 01204 FMP FE&1,1
 01205 STO PN&1,1
 01206 125A LDQ XEP
 01207 FMP 3&33
 01210 FDP HA
 01211 FMP FE&1,1
 01212 STO PEX&1,1
 01213 126A LDQ 3&1
 01214 FMP TN&1,1
 01215 FAD PN&1,1
 01216 STO ENAT&1,1
 01217 127A LDQ 3&14
 01220 FMP TX&1,1
 01221 FAD PEX&1,1
 01222 STO EENR&1,1

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01223 128A	CLA XNAT&1,1	01277	FMP ENAT&1,1	01353	XCA
01224	FDP XN&1,1	01300	STO 10&9	01354	FMP PEX&1,1
01225	STQ FND&1,1	01301	LDQ 30&32	01355	STO 10&3
01226 129A	CLA XENR&1,1	01302	FMP 10&9	01356	LDQ 30&27
01227	FDP XE&1,1	01303	STO 10&10	01357	FMP 10&3
01230	STQ FED&1,1	01304	LDQ ENAT&1,1	01360	STO 10&4
01231 130A	LDQ PN&1,1	01305	FMP ENAT&1,1	01361	LDQ PEX&1,1
01232	FMP PN&1,1	01306	XCA	01362	FMP PEX&1,1
01233	XCA	01307	FMP ENAT&1,1	01363	STO 10&5
01234	FMP PN&1,1	01310	STO 10&11	01364	LDQ 30&26
01235	XCA	01311	LDQ 30&31	01365	FMP 10&5
01236	FMP PN&1,1	01312	FMP 10&11	01366	STO 10&6
01237	STO 10&1	01313	STO 10&12	01367	LDQ 30&25
01240	LDQ 30&32	01314	LDQ ENAT&1,1	01370	FMP PEX&1,1
01241	FMP 10&1	01315	FMP ENAT&1,1	01371	FSB 10&6
01242	STO 10&2	01316	STO 10&13	01372	FAD 10&4
01243	LDQ PN&1,1	01317	LDQ 30&30	01373	FSB 10&2
01244	FMP PN&1,1	01320	FMP 10&13	01374	STO 10&7
01245	XCA	01321	STO 10&14	01375	LDQ FED&1,1
01246	FMP PN&1,1	01322	LDQ 30&29	01376	FMP 10&7
01247	STO 10&3	01323	FMP ENAT&1,1	01377	STO 10&8
01250	LDQ 30&31	01324	FSB 10&14	01400	LDQ EENR&1,1
01251	FMP 10&3	01325	FAD 10&12	01401	FMP EENR&1,1
01252	STO 10&4	01326	FSB 10&10	01402	XCA
01253	LDQ PN&1,1	01327	STO 10&15	01403	FMP EENR&1,1
01254	FMP PN&1,1	01330	CLA 30&7	01404	XCA
01255	STO 10&5	01331	FSB FND&1,1	01405	FMP EENR&1,1
01256	LDQ 30&30	01332	XCA	01406	STO 10&9
01257	FMP 10&5	01333	FMP 10&15	01407	LDQ 30&28
01260	STO 10&6	01334	FAD 10&8	01410	FMP 10&9
01261	LDQ 30&29	01335	FSB RLTGN&1,1	01411	STO 10&10
01262	FMP PN&1,1	01336	STO DRLTGN&1,1	01412	LDQ EENR&1,1
01263	FSB 10&6	01337 131A	LDQ PEX&1,1	01413	FMP EENR&1,1
01264	FAD 10&4	01340	FMP PEX&1,1	01414	XCA
01265	FSB 10&2	01341	XCA	01415	FMP EENR&1,1
01266	STO 10&7	01342	FMP PEX&1,1	01416	STO 10&11
01267	LDQ FND&1,1	01343	XCA	01417	LDQ 30&27
01270	FMP 10&7	01344	FMP PEX&1,1	01420	FMP 10&11
01271	STO 10&8	01345	STO 10&1	01421	STO 10&12
01272	LDQ ENAT&1,1	01346	LDQ 30&28	01422	LDQ EENR&1,1
01273	FMP ENAT&1,1	01347	FMP 10&1	01423	FMP EENR&1,1
01274	XCA	01350	STO 10&2	01424	STO 10&13
01275	FMP ENAT&1,1	01351	LDQ PEX&1,1	01425	LDQ 30&26
01276	XCA	01352	FMP PEX&1,1	01426	FMP 10&13

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01427	STO 10014	01503	FMP 30040	01557 138A	CLA 300
01430	LDQ 30025	01504	XCA	01560	FSB HE1
01431	FMP EENR01,1	01505	FMP W	01561	STO 1001
01432	FSB 10014	01506	CHS	01562	STO 100
01433	FAD 10012	01507	FAD 001,1	01563	LDQ 100
01434	FSB 10010	01510	STO 1001	01564	FMP 100
01435	STL 10015	01511	STO 100	01565	STO 1002
01436	CLA 3007	01512	LDQ 100	01566	LDQ C
01437	FSB FED01,1	01513	FMP 100	01567	FMP 1002
01440	XCA	01514	STO 1002	01570	STO 1003
01441	FMP 10015	01515	LDQ 30041	01571	LDQ B
01442	FAD 1008	01516	FMP 1002	01572	FMP 1001
01443	FSB RL TGE01,1	01517	STO 1003	01573	FAD 3007
01444	STO DRL TGE01,1	01520	LDQ 30039	01574	FAD 1003
01445 132A	CLA DRL TGE01,1	01521	FMP 1001	01575	XCA
01446	FDP XA01,1	01522	FAD 30038	01576	FMP A
01447	FMP XE01,1	01523	FSB 1003	01577	XCA
01450	STO 1001	01524	FDP XA01,1	01600	FMP W
01451	CLA DRL TGN01,1	01525	FMP XN01,1	01601	XCA
01452	FDP XA01,1	01526	STO CTN01,1	01602	FMP F01,1
01453	FMP XN01,1	01527 136A	LDQ F01,1	01603	STO TG01,1
01454	FAD 1001	01530	FMP 30042	01604 139A	LDQ 30018
01455	STO DBL TGE01,1	01531	XCA	01605	FMP TG01,1
01456 133A	LDQ EXD01,1	01532	FMP W	01606	XCA
01457	FMP EXD01,1	01533	CHS	01607	FMP CT01,1
01460	STO 1001	01534	FAD P01,1	01610	STO BG01,1
01461	LDQ 30035	01535	STO 1001	01611 140A	LDQ ENAT01,1
01462	FMP 1001	01536	STO 100	01612	FMP ENAT01,1
01463	STO 1002	01537	LDQ 100	01613	STO 1001
01464	LDQ 30034	01540	FMP 100	01614	LDQ 30035
01465	FMP EXD01,1	01541	STO 1002	01615	FMP 1001
01466	FSB 1002	01542	LDQ 30041	01616	STO 1002
01467	STO 001,1	01543	FMP 1002	01617	LDQ 30034
01470 134A	LDQ EED01,1	01544	STO 1003	01620	FMP ENAT01,1
01471	FMP EED01,1	01545	LDQ 30039	01621	FSB 1002
01472	STO 1001	01546	FMP 1001	01622	STO 0201,1
01473	LDQ 30037	01547	FAD 30038	01623 141A	LDQ EENR01,1
01474	FMP 1001	01550	FSB 1003	01624	FMP EENR01,1
01475	STO 1002	01551	FDP XA01,1	01625	STO 1001
01476	LDQ 30036	01552	FMP XE01,1	01626	LDQ 30037
01477	FMP EED01,1	01553	STO CTE01,1	01627	FMP 1001
01500	FSB 1002	01554 137A	CLA CTN01,1	01630	STO 1002
01501	STO P01,1	01555	FAD CTE01,1	01631	LDQ 30043
01502 135A	LDQ F01,1	01556	STO CT01,1	01632	FMP EENR01,1

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01633 FSB 10E2
 01634 STO P2E1,1
 01635 142A LDQ 30E44
 01636 FMP RNT&1,1
 01637 CHS
 01640 FAD 02E1,1
 01641 STO 10E1
 01642 STO 10
 01643 LDQ 10
 01644 FMP 10
 01645 STO 10E2
 01646 LDQ 30E41
 01647 FMP 10E2
 01650 STO 10E3
 01651 LDQ 30E39
 01652 FMP 10E1
 01653 FAD 30E38
 01654 FSB 10E3
 01655 FDP XA&1,1
 01656 FMP XN&1,1
 01657 STO CTN2&1,1
 01660 143A LDQ 30E45
 01661 FMP RNT&1,1
 01662 CHS
 01663 FAD P2E1,1
 01664 STO 10E1
 01665 STO 10
 01666 LDQ 10
 01667 FMP 10
 01670 STO 10E2
 01671 LDQ 30E41
 01672 FMP 10E2
 01673 STO 10E3
 01674 LDQ 30E39
 01675 FMP 10E1
 01676 FAD 30E38
 01677 FSB 10E3
 01700 FDP XA&1,1
 01701 FMP XE&1,1
 01702 STO CTE2&1,1
 01703 144A CLA CTN2&1,1
 01704 FAD CTE2&1,1
 01705 STO CT2&1,1
 01706 145A CLA 30

01707 FSB HE2
 01710 STO 10E1
 01711 STO 10
 01712 LDQ 10
 01713 FMP 10
 01714 STO 10E2
 01715 LDQ C
 01716 FMP 10E2
 01717 STO 10E3
 01720 LDQ B
 01721 FMP 10E1
 01722 FAD 30E7
 01723 FAD 10E3
 01724 XCA
 01725 FMP A
 01726 XCA
 01727 FMP W
 01730 XCA
 01731 FMP FE&1,1
 01732 STO TG2&1,1
 01733 146A LDQ 30E18
 01734 FMP TG2&1,1
 01735 XCA
 01736 FMP CT2&1,1
 01737 FSB BG&1,1
 01740 STO DBG&1,1
 01741 147A CLA BM&1,1
 01742 FSB BXE&1,1
 01743 FSB BSM&1,1
 01744 FSB BNP&1,1
 01745 FSB BMET&1,1
 01746 FAD BLTG&1,1
 01747 FAD BG&1,1
 01750 STO BT&1,1
 01751 148A CLA DBXE&1,1
 01752 FAD DBSM&1,1
 01753 FAD DBNP&1,1
 01754 FAD DBMET&1,1
 01755 FAD DBLTG&1,1
 01756 FAD DBG&1,1
 01757 STO DBUCK&1,1
 01760 149A CLA NR
 01761 SUB I
 01762 149A1 TZE 150A

01763 TPL E03
 01764 150A CAL 20
 01765 SXD 60E4,4
 01766 TSX 8STH0,4
 01767 PZE 8042
 01770 TSX 8FIL0,4
 01771 LXD 60E4,4
 01772 151A CAL 20
 01773 SXD 60E4,4
 01774 TSX 8STH0,4
 01775 PZE 8043
 01776 TSX 8FIL0,4
 01777 LXD 60E4,4
 02000 152A CAL 20
 02001 SXD 60E4,4
 02002 TSX 8STH0,4
 02003 PZE 8044
 02004 LXD 60E4,4
 02005 153A LDQ PE
 02006 STR
 02007 LDQ NCODE
 02010 STR
 02011 SXD 60E4,4
 02012 TSX 8FIL0,4
 02013 LXD 60E4,4
 02014 154A CAL 20
 02015 SXD 60E4,4
 02016 TSX 8STH0,4
 02017 PZE 8045
 02020 LXD 60E4,4
 02021 155A LDQ T
 02022 STR
 02023 LDQ A
 02024 STR
 02025 SXD 60E4,4
 02026 TSX 8FIL0,4
 02027 LXD 60E4,4
 02030 156A CAL 20
 02031 SXD 60E4,4
 02032 TSX 8STH0,4
 02033 PZE 8046
 02034 LXD 60E4,4
 02035 157A LDQ HE1
 02036 STR

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02037 LDQ B
 02040 STR
 02041 SXD 6004,4
 02042 TSX %FIL0,4
 02043 LXD 6004,4
 02044 158A CAL 20
 02045 SXD 6004,4
 02046 TSX %STH0,4
 02047 PZE 8047
 02050 LXD 6004,4
 02051 159A LDQ HE2
 02052 STR
 02053 LDQ C
 02054 STR
 02055 SXD 6004,4
 02056 TSX %FIL0,4
 02057 LXD 6004,4
 02060 160A CAL 20
 02061 SXD 6004,4
 02062 TSX %STH0,4
 02063 PZE 8048
 02064 LXD 6004,4
 02065 161A LDQ XNT
 02066 STR
 02067 LDQ R
 02070 STR
 02071 SXD 6004,4
 02072 TSX %FIL0,4
 02073 LXD 6004,4
 02074 162A CAL 20
 02075 SXD 6004,4
 02076 TSX %STH0,4
 02077 PZE 8049
 02100 LXD 6004,4
 02101 163A LDQ N1
 02102 STR
 02103 LDQ X
 02104 STR
 02105 SXD 6004,4
 02106 TSX %FIL0,4
 02107 LXD 6004,4
 02110 164A CAL 20
 02111 SXD 6004,4
 02112 TSX %STH0,4

02113 PZE 804A
 02114 LXD 6004,4
 02115 165A LDQ N2
 02116 STR
 02117 LDQ Y
 02120 STR
 02121 SXD 6004,4
 02122 TSX %FIL0,4
 02123 LXD 6004,4
 02124 166A CAL 20
 02125 SXD 6004,4
 02126 TSX %STH0,4
 02127 PZE 804B
 02130 LXD 6004,4
 02131 167A LDQ N3
 02132 STR
 02133 LDQ Z
 02134 STR
 02135 SXD 6004,4
 02136 TSX %FIL0,4
 02137 LXD 6004,4
 02140 168A LXD 2002,1
 02141 CLA J1
 02142 STD 173A2
 02143 PXD 0,1
 02144 STO I
 02145 169A CLA EB1
 02146 FSB 3005
 02147 STO 1001
 02150 CLA BM01,1
 02151 FSB BT01,1
 02152 FSB DBUCK01,1
 02153 FAD V01,1
 02154 FSB 30046
 02155 FDP 1001
 02156 FMP XA01,1
 02157 STO ENRCZ01,1
 02160 170A CLA I
 02161 SUB 2002
 02162 170A1 TZE 171A
 02163 TPL 173A
 02164 TRA 173A
 02165 171A CLA ENRCZ01,1
 02166 STO CZE

02167 172A CLA ENRCZ01,1
 02170 173A STO XUMENR01,1
 173A BSS
 02171 173A1 TXI *01,1,1
 02172 SXD I,1
 02173 173A2 TXL 169A,1
 02174 174A CLA N1
 02175 174A1 TZE E0T
 02176 TPL 175A
 02177 TRA E0T
 02200 175A CLA 30047
 02201 STO SUM
 02202 176A LXD 2001,1
 02203 CLA J1
 02204 STD 177A2
 02205 177A CLA SUM
 02206 FAD ENRCZ01,1
 02207 STO SUM
 02210 177A1 TXI *01,1,1
 02211 177A2 TXL 177A,1
 02212 178A LXD 2001,1
 02213 CLA J1
 02214 STD 179A2
 02215 179A CLA CZE
 02216 FDP SUM
 02217 FMP ENRCZ01,1
 02220 STO XUMENR01,1
 02221 179A1 TXI *01,1,1
 02222 179A2 TXL 179A,1
 02223 180A CLA 30047
 02224 STO SUME
 02225 181A LXD 2001,1
 02226 CLA J1
 02227 STD 182A2
 02230 182A CLA SUME
 02231 FAD XUMENR01,1
 02232 STO SUME
 02233 182A1 TXI *01,1,1
 02234 182A2 TXL 182A,1
 02235 TRA 183A
 02236 E0T SXD C0G1,4
 02237 183A CLA BT01,4
 02240 FSB DBUCK01,4
 02241 FSB V01,4

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02242	FSB 30&48	02316	188A	CLA ENRCZ&1,1	02371		STD 201A2
02243	STO B3	02317		STO EZE	02372	201A	CLA XUMENR&1,1
02244	184A LDQ B3	02320	189A	CLA ENRCZ&1,1	02373		FSB XE&1,1
02245	FMP B3	02321		STO XUMENR&1,1	02374		STO DEL&1,1
02246	XCA		190A	BSS	02375	201A1	TXI *&1,1,1
02247	FMP B3	02322	190A1	TXI *&1,1,1	02376	201A2	TXL 201A,1
02250	STO 10&1	02323		SXD I,1	02377	202A	CAL 20
02251	LDQ Z	02324	190A2	TXL 186A,1	02400		SXD 60&4,4
02252	FMP 10&1	02325	191A	CLA N2	02401		TSX %STH0,4
02253	STO 10&2	02326	191A1	TZE 200A	02402		PZE 804C
02254	LDQ B3	02327		TPL E012	02403		TSX %FIL0,4
02255	FMP B3	02330		TRA 200A	02404		LXD 60&4,4
02256	STO 10&3	02331	E012	SXD C0G1,4	02405	203A	CAL 20
02257	LDQ Y	02332	192A	CLA 30&47	02406		SXD 60&4,4
02260	FMP 10&3	02333		STO SUMX	02407		TSX %STH0,4
02261	STO 10&4	02334	193A	LXD J5,1	02410		PZE 804D
02262	LDQ X	02335		CLA J3	02411		LXD 60&4,4
02263	FMP B3	02336		STD 194A2	02412	204A	LDQ DB
02264	FAD R	02337	194A	CLA SUMX	02413		STR
02265	FAD 10&4	02340		FAD ENRCZ&1,1	02414		SXD 60&4,4
02266	FAD 10&2	02341		STO SUMX	02415		TSX %FIL0,4
02267	STO DB	02342	194A1	TXI *&1,1,1	02416		LXD 60&4,4
02270	185A LXD J2,1	02343	194A2	TXL 194A,1	02417	205A	CAL 20
02271	CLA J3	02344	195A	LXD J5,1	02420		SXD 60&4,4
02272	STD 190A2	02345		CLA J3	02421		TSX %STH0,4
02273	PXD 0,1	02346		STD 196A2	02422		PZE 804E
02274	STO I	02347	196A	CLA EZE	02423		LXD 60&4,4
02275	186A CLA EB2	02350		FDP SUMX	02424	206A	LDQ B3
02276	FSB 30&5	02351		FMP ENRCZ&1,1	02425		STR
02277	STO 10&1	02352		STO XUMENR&1,1	02426		SXD 60&4,4
02300	CLA BM&1,1	02353	196A1	TXI *&1,1,1	02427		TSX %FIL0,4
02301	FSB BT&1,1	02354	196A2	TXL 196A,1	02430		LXD 60&4,4
02302	FSB DBUCK&1,1	02355	197A	CLA 30&47	02431	207A	CAL 20
02303	FAD V&1,1	02356		STO SUMY	02432		SXD 60&4,4
02304	FAD DB	02357	198A	LXD J5,1	02433		TSX %STH0,4
02305	FSB 30&46	02360		CLA J3	02434		PZE 803
02306	FDP 10&1	02361		STD 199A2	02435		TSX %FIL0,4
02307	FMP XA&1,1	02362	199A	CLA SUMY	02436		LXD 60&4,4
02310	STO ENRCZ&1,1	02363		FAD XUMENR&1,1	02437	208A	CAL 20
02311	187A CLA I	02364		STO SUMY	02440		SXD 60&4,4
02312	SUB J2	02365	199A1	TXI *&1,1,1	02441		TSX %STH0,4
02313	187A1 TZE 188A	02366	199A2	TXL 199A,1	02442		PZE 804
02314	TPL 190A	02367	200A	LXD 20&2,1	02443		TSX %FIL0,4
02315	TRA 190A	02370		CLA NR	02444		LXD 60&4,4

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02445 209A CAL 20
 02446 SXD 60&4,4
 02447 TSX %STH0,4
 02450 PZE 805
 02451 TSX %FIL0,4
 02452 LXD 60&4,4
 02453 210A LXD 20&2,1
 02454 CLA NR
 02455 STD 212A2
 02456 211A CLA XN&1,1
 02457 UFA 60
 02460 LRS
 02461 ANA 60&1
 02462 LLS
 02463 ALS 18
 02464 STO KN&1,1
 02465 212A CLA XE&1,1
 02466 UFA 60
 02467 LRS
 02470 ANA 60&1
 02471 LLS
 02472 ALS 18
 02473 STO KE&1,1
 02474 212A1 TXI *&1,1,1
 02475 212A2 TXL 211A,1
 02476 213A CAL 20
 02477 SXD 60&4,4
 02500 TSX %STH0,4
 02501 PZE 806
 02502 LXD 60&4,4
 02503 214A LXD 20&2,1
 02504 CLA NR
 02505 STD 215A2
 02506 215A LDQ KONE&1,1
 02507 STR
 02510 LDQ KN&1,1
 02511 STR
 02512 LDQ TIN&1,1
 02513 STR
 02514 LDQ TN&1,1
 02515 STR
 02516 LDQ KE&1,1
 02517 STR
 02520 LDQ TIX&1,1

02521 STR
 02522 LDQ TX&1,1
 02523 STR
 02524 215A1 TXI *&1,1,1
 02525 215A2 TXL 215A,1
 02526 217A SXD 60&4,4
 02527 TSX %FIL0,4
 02530 LXD 60&4,4
 02531 218A CAL 20
 02532 SXD 60&4,4
 02533 TSX %STH0,4
 02534 PZE 807
 02535 TSX %FIL0,4
 02536 LXD 60&4,4
 02537 219A CAL 20
 02540 SXD 60&4,4
 02541 TSX %STH0,4
 02542 PZE 808
 02543 TSX %FIL0,4
 02544 LXD 60&4,4
 02545 220A CAL 20
 02546 SXD 60&4,4
 02547 TSX %STH0,4
 02550 PZE 809
 02551 LXD 60&4,4
 02552 221A LXD 20&2,1
 02553 CLA NR
 02554 STD 222A2
 02555 222A LDQ KONE&1,1
 02556 STR
 02557 LDQ BXE&1,1
 02560 STR
 02561 LDQ BSM&1,1
 02562 STR
 02563 LDQ BNP&1,1
 02564 STR
 02565 LDQ BMET&1,1
 02566 STR
 02567 LDQ BLTG&1,1
 02570 STR
 02571 LDQ BG&1,1
 02572 STR
 02573 LDQ BM&1,1
 02574 STR

02575 LDQ BT&1,1
 02576 STR
 02577 222A1 TXI *&1,1,1
 02600 222A2 TXL 222A,1
 02601 224A SXD 60&4,4
 02602 TSX %FIL0,4
 02603 LXD 60&4,4
 02604 225A CAL 20
 02605 SXD 60&4,4
 02606 TSX %STH0,4
 02607 PZE 80A
 02610 TSX %FIL0,4
 02611 LXD 60&4,4
 02612 226A CLA XEP
 02613 UFA 60
 02614 LRS
 02615 ANA 60&1
 02616 LLS
 02617 ALS 18
 02620 STO IEXP
 02621 227A CAL 20
 02622 SXD 60&4,4
 02623 TSX %STH0,4
 02624 PZE 80B
 02625 LXD 60&4,4
 02626 228A LDQ IEXP
 02627 STR
 02630 SXD 60&4,4
 02631 TSX %FIL0,4
 02632 LXD 60&4,4
 02633 229A CAL 20
 02634 SXD 60&4,4
 02635 TSX %STH0,4
 02636 PZE 80C
 02637 TSX %FIL0,4
 02640 LXD 60&4,4
 02641 230A CAL 20
 02642 SXD 60&4,4
 02643 TSX %STH0,4
 02644 PZE 80D
 02645 TSX %FIL0,4
 02646 LXD 60&4,4
 02647 231A CAL 20
 02650 SXD 60&4,4

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02651	TSX %STH□,4	02725	239A	LXD 2□&2,1	03001	TRA 1
02652	PZE 8□E	02726		CLA NR	03002	MON 0,0,3
02653	LXD 6□&4,4	02727		STD 240A2	03003	IOT
02654	232A LXD 2□&2,1	02730	240A	LDQ KONE&1,1	03004	2047D1 HPR 1,7
02655	CLA NR	02731		STR	03005	TRA 2047D1
02656	STD 233A2	02732		LDQ V&1,1	03006	2□ OCT &000003000000
02657	233A LDQ KONE&1,1	02733		STR	03007	OCT &000002000000
02660	STR	02734		LDQ XUMENR&1,1	03010	OCT &000001000000
02661	LDQ DBXE&1,1	02735		STR	03011	OCT &000004000000
02662	STR	02736		LDQ DEL&1,1	03012	3□ OCT &207620000000
02663	LDQ DBSM&1,1	02737		STR	03013	OCT &203716560507
02664	STR	02740	240A1	TXI *&1,1,1	03014	OCT &177472445214
02665	LDQ DBNP&1,1	02741	240A2	TXL 240A,1	03015	OCT &201405214052
02666	STR	02742	242A	SXD 6□&4,4	03016	OCT &200560507534
02667	LDQ DBMET&1,1	02743		TSX %FIL□,4	03017	OCT &206637146314
02670	STR	02744		LXD 6□&4,4	03020	OCT &200631463146
02671	LDQ DBLTG&1,1	02745	243A	CAL 2□	03021	OCT &201400000000
02672	STR	02746		SXD 6□&4,4	03022	OCT &175735361004
02673	LDQ DBG&1,1	02747		TSX %STH□,4	03023	OCT &170402777073
02674	STR	02750		PZE 8□2D	03024	OCT &204477757473
02675	LDQ DBUCK&1,1	02751		LXD 6□&4,4	03025	OCT &204516743247
02676	STR	02752	244A	LDQ SUME	03026	OCT &206654000000
02677	233A1 TXI *&1,1,1	02753		STR	03027	OCT &175526331720
02700	233A2 TXL 233A,1	02754		LDQ SUM	03030	OCT &204413146314
02701	235A SXD 6□&4,4	02755		STR	03031	OCT &136660247727
02702	TSX %FIL□,4	02756		LDQ SUMY	03032	OCT &136743260630
02703	LXD 6□&4,4	02757		STR	03033	OCT &133621212471
02704	236A CAL 2□	02760		LDQ SUMX	03034	OCT &173462157052
02705	SXD 6□&4,4	02761		STR	03035	OCT &175621642470
02706	TSX %STH□,4	02762		SXD 6□&4,4	03036	OCT &175503453004
02707	PZE 8□F	02763		TSX %FIL□,4	03037	OCT &177461031312
02710	TSX %FIL□,4	02764		LXD 6□&4,4	03040	OCT &176607126010
02711	LXD 6□&4,4	02765	245A	TRA 45A	03041	OCT &160622516334
02712	237A CAL 2□	02766	246A	CAL 2□	03042	OCT &201467024365
02713	SXD 6□&4,4	02767		SXD 6□&4,4	03043	OCT &172452140524
02714	TSX %STH□,4	02770		TSX %STH□,4	03044	OCT &161461260636
02715	PZE 8□G	02771		PZE 8□30	03045	OCT &146410443652
02716	TSX %FIL□,4	02772		TSX %FIL□,4	03046	OCT &131535016652
02717	LXD 6□&4,4	02773		TSX EXIT,4	03047	OCT &174603366450
02720	238A CAL 2□	02774		LXD 6□&4,4	03050	OCT &162677747201
02721	SXD 6□&4,4	02775		RCD	03051	OCT &147623564137
02722	TSX %STH□,4	02776		RLA *&4	03052	OCT &132671724660
02723	PZE 8□I	02777		LCA	03053	OCT &201447534121
02724	LXD 6□&4,4	03000		TAF *&3	03054	OCT &200776066042

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03055	OCT	&164736115105	03131	8□4C	BCD 1 %	03205	BCD 1# F8.4
03056	OCT	&200655442641	03132		BCD 1□	03206	BCD 11X,3HA
03057	OCT	&164464044531	03133		BCD 1 E12.4	03207	BCD 1F6.2,1
03060	OCT	&202506314631	03134		BCD 1X,3HZ#	03210	BCD 1,3HT#
03061	OCT	&172530040611	03135		BCD 1 I2,14	03211	BCD 11H 45X
03062	OCT	&171740301771	03136		BCD 1,4HN3#	03212	8□45 BCD 1 %
03063	OCT	&156500617431	03137		BCD 11H 45X	03213	BCD 1I2□
03064	OCT	&172404652507	03140	8□4B	BCD 1 %	03214	BCD 1CODE#
03065	OCT	&200634530040	03141		BCD 1□	03215	BCD 12X,7HN
03066	OCT	&175461761202	03142		BCD 1 E12.4	03216	BCD 1F5.2,1
03067	OCT	&175634035373	03143		BCD 1X,3HY#	03217	BCD 1,3HP#
03070	OCT	&206501341217	03144		BCD 1 I2,14	03220	BCD 11H045X
03071	OCT	&000000000000	03145		BCD 1,4HN2#	03221	8□44 BCD 1 %
03072	OCT	&204567024365	03146		BCD 11H 45X	03222	BCD 1TA□
03073	6□ OCT	&233000000000	03147	8□4A	BCD 1 %	03223	BCD 1PUT DA
03074	OCT	&0000000377777	03150		BCD 1□	03224	BCD 1,10HIN
03075	OCT	&000000000000	03151		BCD 1 E12.4	03225	BCD 11H055X
03076	OCT	&0000001000000	03152		BCD 1X,3HX#	03226	8□43 BCD 1 %
03077	OCT	&000000000000	03153		BCD 1 I2,14	03227	BCD 1ECK□
03100	OCT	&000000000000	03154		BCD 1,4HN1#	03230	BCD 1NT N P
03101	BCD	1#F9.2□	03155		BCD 11H 45X	03231	BCD 1,11HHU
03102	BCD	1EGION	03156	8□49	BCD 1 %	03232	BCD 11H155X
03103	BCD	1INGE R	03157		BCD 12.4□	03233	8□42 BCD 1 %
03104	BCD	1 IN FR	03160		BCD 1HR# E1	03234	BCD 1CTOR□
03105	BCD	1CKLING	03161		BCD 1,10X,3	03235	BCD 1IN REA
03106	BCD	1,27HBU	03162		BCD 1# F5.0	03236	BCD 1ENING
03107	BCD	11H 42X	03163		BCD 1,5HXNT	03237	BCD 1 FLATT
03110	8□4E BCD	1 %	03164		BCD 11H 45X	03240	BCD 1M ZONE
03111	BCD	1#F9.2□	03165	8□48	BCD 1 %	03241	BCD 1PERFOR
03112	BCD	1EGION	03166		BCD 1.4□	03242	BCD 1AM TO
03113	BCD	1RING R	03167		BCD 1HC# F8	03243	BCD 1 PROGR
03114	BCD	1 IN E-	03170		BCD 1,10X,3	03244	BCD 1CK - A
03115	BCD	1CKLING	03171		BCD 1# F5.2	03245	BCD 1T N PE
03116	BCD	1,27HBU	03172		BCD 1,5HHE2	03246	BCD 161HHUN
03117	BCD	11H 42X	03173		BCD 11H 45X	03247	BCD 11H08X,
03120	8□4D BCD	1 %	03174	8□47	BCD 1 %	03250	8□3P BCD 1 %
03121	BCD	10.0 □	03175		BCD 1.4□	03251	BCD 1D□
03122	BCD	1 #	03176		BCD 1HB# F8	03252	BCD 1STOPPE
03123	BCD	1REGION	03177		BCD 1,10X,3	03253	BCD 1 SO I
03124	BCD	1INTRAL	03200		BCD 1# F5.2	03254	BCD 1E ZERO
03125	BCD	1 IN CE	03201		BCD 1,5HHE1	03255	BCD 1D TO B
03126	BCD	1CKLING	03202		BCD 11H 45X	03256	BCD 1S FOUN
03127	BCD	1,36HBU	03203	8□46	BCD 1 %	03257	BCD 1ASE WA
03130	BCD	11H042X	03204		BCD 1□	03260	BCD 1,39HIC

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03261	BCD 11H112X	03335	8aG	BCD 1	%	03411	BCD 12X,5HD
03262	8a30	BCD 1	%	03336	BCD 1a	03412	BCD 1ELTA,1
03263	BCD 1,F5.1a	03337		BCD 1Y ZONE		03413	BCD 1 HD
03264	BCD 15.1,4X	03340		BCD 1NGES B		03414	BCD 1,11X,5
03265	BCD 11,4X,F	03341		BCD 1NG CHA		03415	BCD 1HDELTA
03266	BCD 14X,F5.	03342		BCD 1ATTENI		03416	BCD 1A,8X,5
03267	BCD 1,F5.1,	03343		BCD 1,26HFL		03417	BCD 15HDELT
03270	BCD 11H044X	03344		BCD 11H147X		03420	BCD 1A,10X,
03271	8a2D	BCD 1	%	03345	8aF	03421	BCD 15HDELT
03272	BCD 1.1a	03346		BCD 1,F6.2a		03422	BCD 1TA,7X,
03273	BCD 1.4,2F5	03347		BCD 16.2,6X		03423	BCD 1,5HDEL
03274	BCD 12,3E11	03350		BCD 1 ,F		03424	BCD 11H020X
03275	BCD 1.4,F6.	03351		BCD 1.2,12X		03425	8aC
03276	BCD 112,3F7	03352		BCD 110X,F6		03426	BCD 1,13a
03277	8a1N	BCD 1	%	03353		03427	BCD 11H&69X
03300	BCD 1a	03354		BCD 16.2,7X		03430	8aB
03301	BCD 112F6.2	03355		BCD 12,8X,F		03431	BCD 1a
03302	8a1C	BCD 1	%	03356		03432	BCD 1POSURE
03303	BCD 1,F5.1a	03357		BCD 1,F6.2,		03433	BCD 1TON EX
03304	BCD 1.1,10X	03360		BCD 1,12,6X		03434	BCD 1 MWD/
03305	BCD 110X,F5	03361		BCD 11H 11X		03435	BCD 1TER
03306	BCD 1,F6.2,	03362	8aE	BCD 1	%	03436	BCD 1ONE AF
03307	BCD 1,12,7X	03363		BCD 1La		03437	BCD 1E IN Z
03310	BCD 11H 37X	03364		BCD 15HTOTA		03440	BCD 1 CHANG
03311	8aI	03365		BCD 1TE,6X,		03441	BCD 1CKLING
03312	BCD 1ANGEa	03366		BCD 1GRAPHI		03442	BCD 1LTA BU
03313	BCD 1X,6HCH	03367		BCD 1,6X,8H		03443	BCD 1,56HDE
03314	BCD 1EDED,9	03370		BCD 1-GAINS		03444	BCD 11H133X
03315	BCD 1X,6HNE	03371		BCD 1G-TERM		03445	8aA
03316	BCD 1INGS,7	03372		BCD 115HLON		03446	BCD 1,F6.2a
03317	BCD 1HBUCKL	03373		BCD 1AL,6X,		03447	BCD 16.2,5X
03320	BCD 1E,5X,9	03374		BCD 1,5HMET		03450	BCD 12,7X,F
03321	BCD 1,4HZON	03375		BCD 1 6X		03451	BCD 1 6.
03322	BCD 11H 36X	03376		BCD 1UNIU,		03452	BCD 1,11X,F
03323	8aH	03377		BCD 19HNEPT		03453	BCD 1X,F6.2
03324	BCD 1NTa	03400		BCD 1UM,6X,		03454	BCD 1F6.2,9
03325	BCD 1RICHME	03401		BCD 1SAMARI		03455	BCD 1.2,6X,
03326	BCD 1,10HEN	03402		BCD 1,6X,8H		03456	BCD 1,7X,F6
03327	BCD 1ENT,5X	03403		BCD 1HXENDN		03457	BCD 1X,F6.2
03330	BCD 1NRICHM	03404		BCD 1E,6X,5		03460	BCD 1F6.2,6
03331	BCD 1X,10HE	03405		BCD 1,4HZON		03461	BCD 112,5X,
03332	BCD 1TROL,6	03406		BCD 11H 10X		03462	BCD 11H 8X,
03333	BCD 1,7HCON	03407	8aD	BCD 1	%	03463	8a9
03334	BCD 11H046X	03410		BCD 1ELTAa		03464	BCD 1a

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03465	BCD 1HTOTAL	03541	BCD 11H 13X	03615	BCD 1.0,F5.
03466	BCD 1 ,5	03542 8□6	BCD 1 %	03616	BCD 17.0,F5
03467	BCD 1IAL,5X	03543	BCD 1□	03617	BCD 1F7.0,F
03470	BCD 1HMATER	03544	BCD 1POSURE	03620	BCD 1,F5.0,
03471	BCD 1E,5X,8	03545	BCD 1X,8HEX	03621	BCD 13,F5.3
03472	BCD 1RAPHIT	03546	BCD 1SURE,8	03622	BCD 113,F5.
03473	BCD 15X,8HG	03547	BCD 18HEXPO	03623 8□2	BCD 1 %
03474	BCD 1GAINS,	03550	BCD 1KE,8X,	03624	BCD 113,13□
03475	BCD 1-TERM-	03551	BCD 1,5HSPI	03625	BCD 1.0,13,
03476	BCD 15HLONG	03552	BCD 1 8X	03626	BCD 15.2,F5
03477	BCD 1L,5X,1	03553	BCD 1OSURE,	03627	BCD 1F5.2,F
03500	BCD 15HMETA	03554	BCD 1,8HEXP	03630	BCD 1,F6.1,
03501	BCD 1 X,	03555	BCD 1URE,8X	03631	BCD 12,F6.3
03502	BCD 1NIUM,5	03556	BCD 1HEXPOS	03632	BCD 113,F5.
03503	BCD 1HNEPTU	03557	BCD 1L,8X,8	03633 8□1	BCD 1 %
03504	BCD 1M,5X,9	03560	BCD 1NATURA		
03505	BCD 1AMARIU	03561	BCD 1,8X,7H		
03506	BCD 15X,8HS	03562	BCD 14HZONE		
03507	BCD 1XENON,	03563	BCD 11H 12X		
03510	BCD 1,5X,5H	03564 8□5	BCD 1 %		
03511	BCD 14HZONE	03565	BCD 1SPIKE□		
03512	BCD 11H07X,	03566	BCD 111X,5H		
03513 8□8	BCD 1 %	03567	BCD 1SPIKE,		
03514	BCD 1 □	03570	BCD 123X,5H		
03515	BCD 10BUCKS	03571	BCD 1TURAL,		
03516	BCD 1N MICR	03572	BCD 1X,7HNA		
03517	BCD 1DOWN I	03573	BCD 1URAL,8		
03520	BCD 1T SHUT	03574	BCD 1,7HNAT		
03521	BCD 1DATA A	03575	BCD 11H 40X		
03522	BCD 1KLING	03576 8□4	BCD 1 %		
03523	BCD 1NE BUC	03577	BCD 1RTUP□		
03524	BCD 1,45HZO	03600	BCD 1,7HSTA		
03525	BCD 11H137X	03601	BCD 1OWN,8X		
03526 8□7	BCD 1 %	03602	BCD 1HSHUTD		
03527	BCD 1.2□	03603	BCD 1,22X,8		
03530	BCD 1 F6	03604	BCD 1TARTUP		
03531	BCD 12,10X,	03605	BCD 18X,7HS		
03532	BCD 10X,F6.	03606	BCD 1TDOWN,		
03533	BCD 1X,14,1	03607	BCD 1,8HSHU		
03534	BCD 1F6.2,9	03610	BCD 11H139X		
03535	BCD 12,10X,	03611 8□3	BCD 1 %		
03536	BCD 11X,F6.	03612	BCD 1F5.0□		
03537	BCD 1X,14,1	03613	BCD 1,F7.0,		
03540	BCD 1,12,10	03614	BCD 10,F7.0		

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