NOTICE

CERTAIN DATA CONTAINED IN THIS DOCUMENT MAY BE DIFFICULT TO READ IN MICROFICHE PRODUCTS.

HW--64164

DE93 010227

UNCLASSIFIED

(CLASSIFICATION)

GENERAL ELECTRIC

HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

COPY NO. 25 COPY 1 MICROFILM

DATE February 1, 1960

ISSUING FILE

CIRCULATING COPY
RECEIVED 300 AREA
MAR 17 1960
RETURN TO
TECHNICAL INFORMATION FILES

TITLE

FUEL ELEMENT HANDLING BEFORE IRRADIATION

AUTHOR

S. J. Gilbert

ROUTE NO.	PAYROLL NO.	LOCATION	FILES ROUTE DATE	SIGNATURE AND DATE
Extra				
J M Foster	12631	105C	MAR 2 0 1960	[illegible]
H A Ford	21478	1704F		[illegible] 1 26 61

MASTER

DISTRIBUTION RESTRICTED TO U.S. ONLY

UNCLASSIFIED

(CLASSIFICATION)

(6-58)

DO NOT USED ON UNCLASSIFIED AND OFFICIAL USE ONLY DOCUMENTS

UNCLASSIFIED

HW-64164

C 25

1.	CR Barker	12.	CA Priode
2.	RT Beaver	13.	RW Reid
3.	RE Berg	14.	LF Reinig
4.	JH Brown	15.	W Seeburger
5.	AC Callen	16.	SH Small
6.	RL Diekeman	17.	JT Stringer
7.	RD Gilbert	18.	WW Windsheimer
8.	HW Heacock	19.	EC Wood
9.	PC Jerman	20.	300 Files
10.	RT Jessen	21.	Record Center
11.	JJ Mains	22 - 31	Extra

March 10, 1960

G. E. Gratten, Supervisor
Industrial Engineering
Plant and Industrial Engineering

FUEL ELEMENT HANDLING BEFORE IRRADIATION

The attached report on fuel element handling presents in some detail the current status of an engineering study which has been underway for some time, and which is continuing. The study was undertaken to determine if it is economically feasible, and if it is practicable, to revise the method and equipment used for fuel element handling with existing charging machines.

The successful development of new and improved fuel element handling systems requires the integrated efforts of personnel in IPD and in FPD. At this time, it is deemed advisable to establish a formal information exchange on the status of the work. Current joint efforts in FPD and IPD are designed to develop methods, and to test hardware for handling fuel elements in the fuel cells which are described in the report.

The attached report includes also statements, conclusions and recommendations for future action for your consideration. These conclusions and recommendations are expected to focus attention on all parts of the material handling, and fuel element charging system of human and material resources.

R. D. Gilbert
Industrial Engineering
Plant and Industrial Engineering

RD Gilbert:jh

FUEL ELEMENT HANDLING BEFORE IRRADIATION

INTRODUCTION

The method of feeding fuel elements into Hanford reactors influences reactor productivity. The effectiveness of any handling method is influenced by upstream and downstream conditions. Upstream conditions refer to storage, original packaging, inter-area transportation, and rehandling within the using area. Downstream conditions refer to the free-fall characteristics of those fuel elements which are displaced by newly-charged elements.

The study of fuel element handling was initiated as the first phase of an overall FY-1962 budget study and as the economic evaluation of current alternatives for immediate handling needs.

Within the upstream and downstream limits imposed by present type on-reactor charge machines, this study attempts to meet the following objectives:

1. Improve the utilization of HAPO reactor resources during necessary outage time.

2. Reduce the unit cost of HAPO product.

The most immediate effort toward these objectives appears to be the:

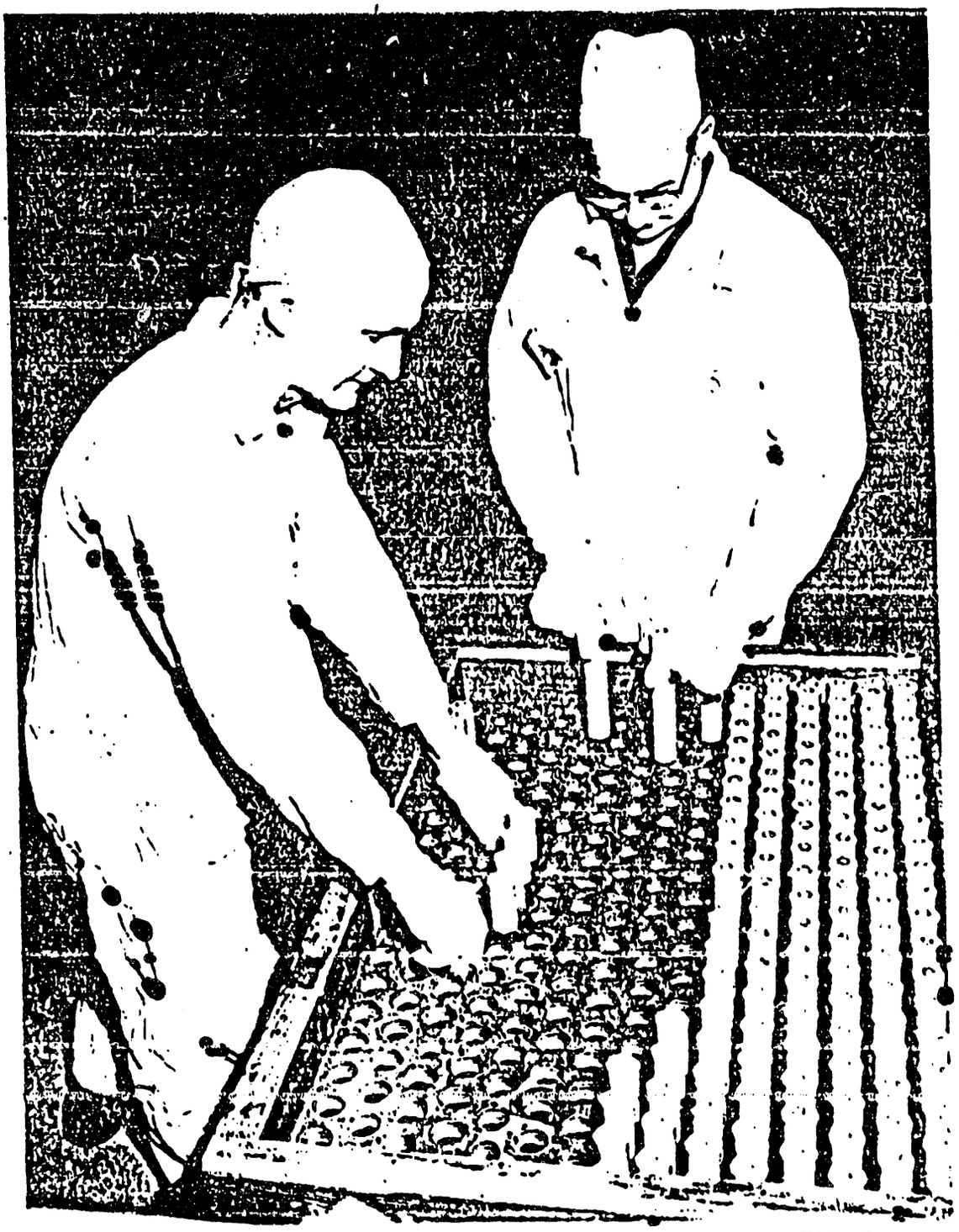
a. Obtaining consistent rates of machine and reactor performance.

b. Assuring timely delivery of appropriate material.

c. Integrating the needs of FPD (fuel supplier) with the needs of FPD (fuel user).

Within this framework, the study considers the comparative HAPO needs and economics of packaging fuel elements as if they were 1) eggs, 2) large ammunition, or 3) sections of bamboo poles.

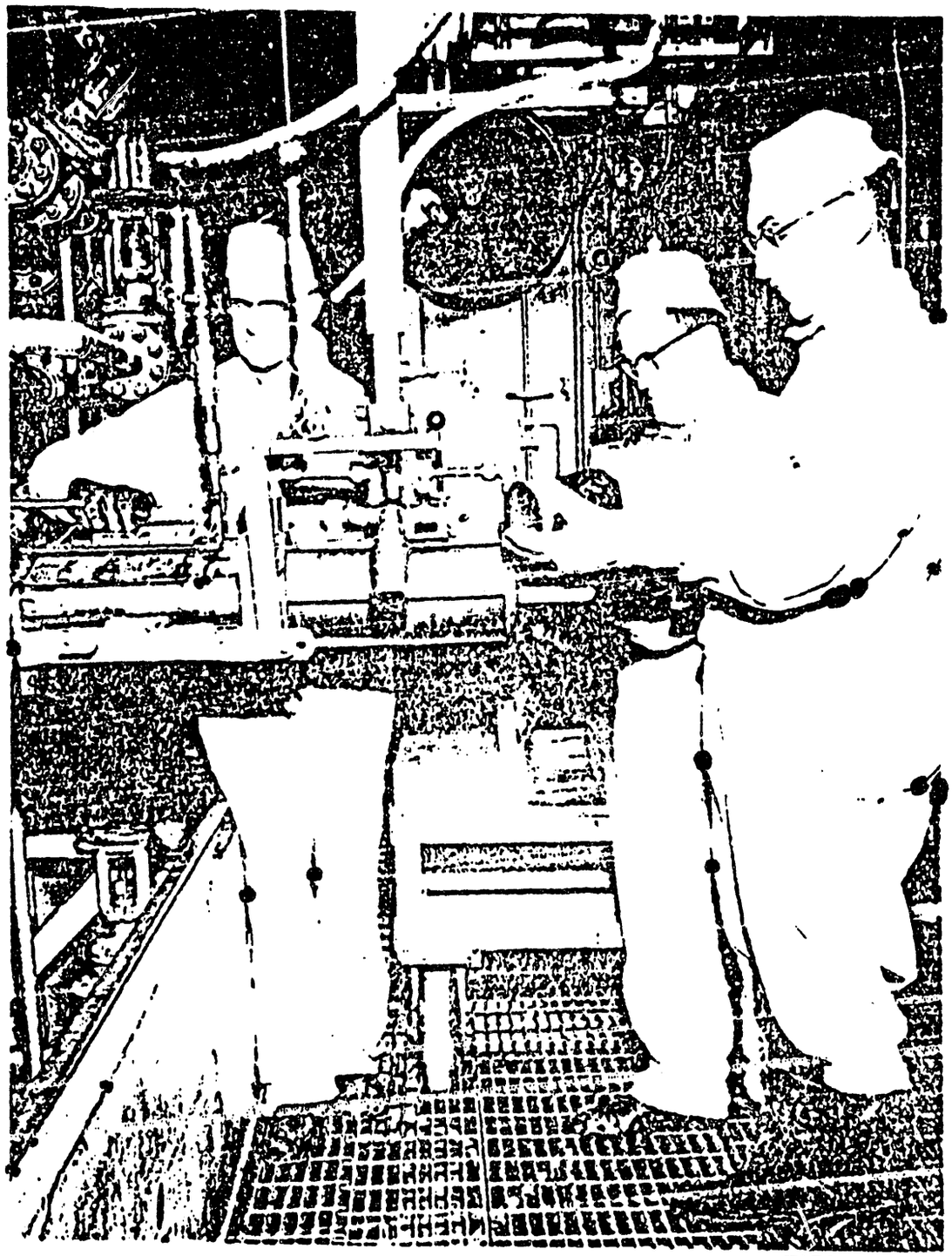
The following pictures from the December [illegible], 1959, issue of the HAPO GE News (Exhibits I and II) show the type of fuel packaging and charging equipment that is currently in use.



HAPO GE News
Dec. 31, 1959

EXHIBIT I

Fuel Element Handling - 300 Hole Pallet



HAPO GE News
Dec. 31, 1959

EXHIBIT II

Fuel Element Handling
From Charge Box into Charge Machine

BACKGROUND

The concepts of handling fuel elements at HAPO have progressed from "absolute accountability" for a scarce, strategically classified, personally handled type of material to the need for a low unit cost, non-injuring storage, and mechanized delivery of a relatively valuable, internationally common material.

Original delivery of fuel elements was accomplished in solid wood blocks, approximately 4" x 8" x 6" with 8 drilled holes to support fuel elements. At the completion of their processing in fuel fabrication, these blocks were loaded into trucks and delivered with a patrol guard to the reactors. The fuel elements were then inserted one-at-a-time into a process tube with a hand-crank fixture. As the capacity of fuel fabrication grew to meet or excell the immediate rate of reactor demand, the 8-unit wood blocks were replaced by stackable pallets having capacity for 200 fuel elements. Subsequently, hi-lift fork trucks became more generally used throughout HAPO for fuel handling, and replacement pallets were designed with a capacity of 300 fuel elements.

One consequence of storing elements in 200 or 300-hole pallets is the need for reloading each fuel element into a "charge box" before sending it onto the work elevator. Current methods require an additional handling of each element as it is lifted by hand into the mechanical charge machine shown in Exhibit II.

The enclosed picture of a current charge machine (Exhibit II) reveals that the material loading is accomplished by one man. This task can be measured as approximately 1,100 ft lb/minute, disregarding the energy required for the body movement of the man and adding 4 pounds (as the weight of the man's forearm) to the 8-pound weight of the fuel element. To have consistent charging rates with present equipment, this rate of work by one body member must be sustained regularly through a shift. PRODUCT ENGINEERING (December 28, 1959, p. 10) cites that a good athlete has an overall "cruising power" of about 10,000 ft lb/minute. Recent experiments at providing charge operators 50 percent rest during their shift have achieved higher-than-usual charging rates. However, full utilization of reactor outage time already requires a peak size operating crew during the charge-discharge operation.

The existing charge machines and other front face hardware provide opportunity for a charging rate of 100 tubes every 1.4 hours. This rate has been exceeded for a short period in 105-F when 100 tubes were charged within 1.3 hours. The average charging rates are closer to 100 tubes in 2.1 hours. This 60 percent difference in rates of consistent performance is due to work practices and to utilization of equipment. As much as a quarter of this difference (15 percent gain) might be assigned as incentive for improved material handling equipment, assuming that such equipment is compatible with existing machinery and HAPO work practices. The apparent need for additional operating personnel during the charge-discharge operation makes investment in fixtures and labor-saving equipment appear more attractive.

SUMMARY, RECOMMENDATION, AND CONCLUSIONS

The analysis of fuel element handling cost has been summarized on the attached table of unit cost comparisons. The most attractive means for storage, delivery, and feed to IPD charge machines is the "clip" option (No. 4). With either existing or proposed type charge machines, this option provides high-density storage, charge-oriented loading, charge-size transportation by overhead monorail, bulk transportation by hi-lift truck and regular vans, linear-programed charging sequence, gravity-flow delivery of fuel elements, and minimum dead weight on reactor elevators. The iron clip is expected to have a working life equal to or greater than twice the working life of fuel packages made from wood. Based on this assumption, fuel clips can be used at 24 percent less unit cost than present fuel pallets. (The unit of comparison is 1,000 fuel elements.)

It is recommended that discarded pallets be replaced with fuel clips. The initial order of fuel clips should be adequate to service one reactor completely. Presently used 300-hole pallets that are in good condition should be retained for relative dead storage. This assumes that FPD can manage its inventory of finished product on a modified last-in, first-out basis. Fuel inventory management can minimize the number of fuel clips required. (This high utilization can shorten the justification period.)

Mechanical equipment can be built for approximately $5,000 to transfer fuel elements from pallet storage to clips. All HAPO charge machines can be equipped with adapters to allow gravity feed from charge clips to either existing or proposed charge machine feed mechanisms.

STATEMENT OF THE PROBLEM

"How should fuel elements be packaged and handled between the last manufacturing operation in FPD and the appropriate positioning of individual fuel elements for their insertion into the reactor." The specific subproblems to this statement are: "What is the least-cost manner for loading, storing, transporting, and unloading the fuel element packages" and "How should fuel elements be arranged to minimize the reactor outage time needed to insert fuel elements into appropriate reactor tubes."

Presently used fuel pallets have proved satisfactory as a storage and mass-delivery medium. Fully effective fuel element rehandling during the charging operation requires more manpower than is currently available on a consistent basis. The influence of personal fatigue is to reduce reactor utilization. Initial cost and life expectancy of fuel element packaging is expressed on the attached unit cost comparison chart.

The upstream processor (FPD) is aware of the relatively short life (est. 5 years, 12 trips/year) of wood containers. The forthcoming change in effective diameter will require that pallets be overbored to accommodate self-supported fuel elements.

The high initial cost, the relatively loose arrangement of fuel elements, and the low storage density in K-type magazines have precluded their use as storage and inter-area transportation containers. The criteria thus evolved for least-cost fuel handling between producer and user includes a minimum summation of the following cost factors.

1. Annual cost of adequate manpower to service any reactor which requires charging.

2. Annual cost for fabrication and maintenance of fuel containers.

3. Annual cost for space to store current inventory of finished material. The landlord cost of 12¢/square foot/month is particularly realistic when a new building must be constructed for storage.

4. Annual cost of inter-area highway transportation is generally the same for packages allowing use of full weight capacity of the van.

5. Annual cost of special jigs or fixtures for mechanical transfer from one type of handling package to another.

ALTERNATIVE SOLUTIONS - DESCRIPTION AND EVALUATION

The alternative material handling solutions are dependent on the manner in which the fuel element is held in its package. The first two alternatives hold the fuel element on end like a peg. The next two alternatives let the fuel elements lie side by side during transportation and rely, in varying measures, on the force of gravity to unload the package. The third set of solutions orients the fuel elements into an end-to-end column of fuel elements.

Option 1 is the present 300-hole pallet that is shown in the picture on page 1 of this report (Exhibit I). One merit is its acceptance within FPD. It has a low initial cost, it can be repaired with carpenter tools, and it can be stacked high enough to achieve floor loadings of 1,000 pounds per square foot. The minimum requirement for hand labor in loading and unloading brings the unit cost per 1,000 fuel elements to a fourth most attractive position within the comparison. The expected labor cost associated with this handling media is approximately equal to the most expensive position within the comparison.

Option 2 is an adaption of the existing type pallet which allows the individual rows of the pallet to be separable into "charge boxes" of approximately half a standard charge. Fuel elements in such a horizontal and parallel configuration can be lifted to existing type charge machine trays with relatively simple mechanization. The additional cost of modifying short-life wooden pallets left this option as the second most-attractive.

Option 3 is a multiple-layer tray to fit into the K-type charging machines. The all-aluminum magazine is expensive to manufacture and its low compressive strength has precluded stacking full K magazines.

Option 4 is an angle iron frame or "clip" in which fuel elements are packed in a zigzag formation which assures pure rolling contact as they flow out the bottom of the "clip." A stopping cam at the bottom of the clip is designed to allow shut-off between any two fuel elements. The neoprene-coated vertical sides assure a positive flow, even for non-round units. The zigzag configuration of fuel elements and the cam-type door allow a wide range of sizes to be accommodated in the same type clip.

Clips can be handled by monorail, roller conveyor, or fork-lift trucks. A double flange wheel at the top of each clip will support it and allows transport along a monorail. The double flange wheel, such as that used to support sides of beef in meat packing plants, allows empty clips to be lifted off the bar type monorail with easy human effort (a 25-pound lift). Iron rods can be fed through holes at the corners of the clips to provide a rigid coupling of up to 8 clips. This self-supporting block can be moved along a roller conveyor or picked up on one tine of a hi-lift fork truck. (The "tine space" for each clip is immediately beneath the clip's top horizontal bar.)

With these features, the fuel clip meets criteria of:

1. Either hand or mechanical loading.

2. Either manpower or lift-truck movement in the dock area.

3. Either floor or monorail (or both) suspension for storage.

4. Either controlled or automatic feed to existing type charge machines.

5. Provision for pre-planning the types of fuel charges to be delivered to the reactor.

6. Low unit cost of a neoprene-protected angle iron frame.

This minimum unit cost and opportunity for greater reactor utilization, when added to the flexibility described above, leave no doubt as to the attractiveness of the fuel charge clip for ultimate fuel handling.

Note: Should FFD managers continue to use some existing type pallets for flexibility in their storage capacity, a $5,000 mechanical-loading machine may be developed for transferring fuel from existing type pallets to fuel element clips.

Option 5 is a configuration of tubes from which fuel elements may be pushed into a regular process tube at approximately double the present maximum charge rate. A heavy, long, horizontal column of fuel elements requires

a unique bending strength if it is to be lifted from one point. If the tube assemblies are the sole means of handling fuel elements, the manufacturing cost of the tubes would be great and storage density would be low. This type of fuel handling assembly and its charge machine offers a gross incentive of up to $260/1,000 fuel elements in terms of reactor utilization. The optimum material handling system appears to require mechanical rehandling from an inexpensive transportation "package" to an effective "column charging" assembly.

Option 6 is a configuration of fuel elements suspended on a cable through their centers. These sub-assemblies could be used in the FPD autoclave operation, and in the same container assembly could be delivered to the reactor areas. Each sub-assembly of fuel elements could be turned to a horizontal position on a roller conveyor. After its center core is removed, the fuel elements would be ready for charging into an Option 5 type tube charge or a single roller conveyor long enough to hold a full tube charge. This "bead" option is dependent on major changes in the layout of the process in FPD, and at first estimate, was only the third most-attractive alternative from a unit cost comparison.

ASSUMPTIONS

The assumptions included within this study include:

1. Wooden pallets have an average life of 5 years and an average use of 12 delivery cycles per year.

2. Metal fuel containers (steel or aluminum) will have at least double the handling life of wood; use, 120 cycles.

3. Storage cost for finished product is 12¢/square foot/month in the 300 Area. Finished product storage averages one month. Reducing the storage space utilized for finished product will benefit FPD.

4. Material handling labor now required during the charge operation can be diverted usefully to other tasks, such as basin work which must be done simultaneously.

5. Manpower required during charge operation only has a peak demand, multiplying influence on costs when additional manpower must be committed within IPD to perform only during the charging activity. The man whose useful performance is limited to the periods of IPD charging is only 25 percent useful. His average unit costs for performing work become 4 times as great as his average hourly overall costs.

6. Present fuel handling system within reactor buildings is influenced by the "bottleneck" at the fuel loading elevator. Existing methods

and equipment allow a maximum of 85 tube charges per hour to be delivered to the work elevator when it is near the delivery top of the reactor. (This capacity approaches the sustained charging rate of 76 tubes per hour which has been accomplished for a short period in F Reactor.)

7. A gravity flow fuel handling system in the B reactors demonstrates the consistency and higher rates of machine operation when the fuel is supplied by a magazine. However, it is possible to induce delays during magazine connection which equal or offset the improved machine performance.

8. The conversion of K charge machines to allow feed from a clip and monorail arrangement or to index a full magazine without delay is expected to improve utilization of K reactors by approximately $250 per 1,000 elements.

9. Bound fuel elements can roll from a fuel clip onto the fuel-receiving tray of existing charge machines. An empty clip can be removed from the monorail while the machine is being fed from its fuel-receiving tray. The tray can carry 3 or 4 "dummies" for immediate charging after the machine has been positioned in front of the tube and connected to its charge clip.

10. The fuel elements can be discharged mechanically from a "clip" into a "gatling gun" tube assembly or into the fuel orientation device of other type charge machines.

11. The equipment costs for transferring fuel elements from one type package to another can be estimated from the following cost elements:

From fuel clip to roller conveyor	$ 500
From fuel clip to tube loader	$ 500
From existing pallets to lateral conveyor	$4,000 - $1,000 inst.
From lateral conveyor to fuel clip	$4,000 - $1,000 inst.

12. Charge machines of the continuous fuel column principle have a gross incentive of approximately $260 per 1,000 elements greater than charge machines (and effective crews) employing the principle of individually charged elements.

13. The "bead" assembly of fuel elements includes potential benefits within the FPD process <u>if</u> their sequence of products is changed, and <u>if</u> all major production is internally cooled and externally supported.

14. Eventual use of water soluble "<u>zincilate</u>" as a fuel element surface protection will minimize galling effect of aluminum-to-aluminum contact.

JUSTIFICATION

Present handling cost/1,000 fuel elements = $10.56 to 18.71: Use $15

Proposed handling cost/1,000 fuel elements = 7.98 : Use 8

Gain in unit cost/1,000 by converting = 2.58 to 10.72: Use 7

Conclusion: It is attractive to replace worn-out pallets or to increase fuel package capacity by using fuel element clips.

Number of cycles required to justify complete, immediate conversion to fuel element clips, without exhausting remaining life of wooden pallets:

Purchase price of clips = $750/1,000 elements of storage capacity

$\frac{\$750}{\$8}$ = 125 clips or 1 clip/week for 2.5 years

Assume that a 15 percent charge rate improvement can be achieved by fuel clip.

$$\frac{\$750 \text{ cost/1,000 fuel element capacity}}{\$202 \text{ utilization improvement/1,000 elements}} = 3.7 \text{ cycles}$$

Assuming at least one cycle/month, fuel clips will justify themselves within 3/3 years even disregarding the sunk cost of wooden pallets.

From a critical mass standpoint, iron racks are superior to wooden pallets for fuel storage. Wood is a relative moderator, and a wood fire is an invitation to additional water moderator. The neutron absorption and deceleration within iron helps ensure against a criticality incident. Iron allows a more dense concentration of fuel elements. (New radiation standards might allow slightly enriched fuel to be mixed with regular fuel within the same tube to improve conversion efficiency.)

R. D. Gilbert
Industrial Engineering Operation
FACILITIES ENGINEERING OPERATION
IRRADIATION PROCESSING DEPARTMENT

RDG:vw
2-1-60

UNCLASSIFIED

UNIT COST COMPARISON FOR FUEL ELEMENT HANDLING

Nature of Fuel Element Package	Cost per 1000 Elements Delivered Between 300 Area & 105 Charging Machine: Material	Storage	Labor	Net Cost	Equiv $ Gain in Reactor Utilization	Associated Problems
.) Present 300-hole pallets & charge trays (Handle [illegible] eggs or pegs)	$5.73	[illegible]80	[illegible]4.03	$10.56	No Gain, No Loss	Remaining 200-hole pallets to be replaced w/300-hole capacity, unless better alternative is justified. Holes must be overbored to handle self-supported fuel elements.
.a) Cost of full utilization using Method 1	---	---	12.18	[illegible].71	E[illegible] $10[illegible]-200 gain	
[illegible] 300-hole pallet[illegible] with separable rows (Allow deliv. of fuel charges w/o indiv. fuel handling)	6.[illegible]	.80	2.50	[illegible]	[illegible]o Gain, [illegible]o Loss	Separable rows have capacity for mechanical loading & unloading.
2a) Cost of full utilization using Method 2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]t $100-200 gain	
.) Tray assembly allows elements to roll with gravity into charge machine. Operating examples in K reactors.	10.0[illegible]	7.68	1.30	[illegible]	Gain Equals Loss	Increased [illegible] of charge machine approximately overcomes delay in attaching K-type magazine. Self-supported fuel elements require steep angles. Strength of aluminum magazine precludes stacking.
.) Clip assembly similar to [illegible] feed. This allows gravity flow of round or non-round elements of standard & large O.D.	6.18	.5[illegible]	[illegible]30	[illegible].08	E[illegible] $202 [illegible]	Loading from pallets or conveyors to be accomplished by hand or machine. Open top & front assist hand loading (machine to be designed). Existing storage capac. for finished elements is doubled. Added density requires assurance that ceiling & floor will support load. Existing or proposed charge mach. can accept fuel [illegible]

UNIT COST COMPARISON FOR FUEL ELEMENT HANDLING (cont'd)

Nature of Fuel Element Package	Cost per 1000 Elements Delivered Between 300 Area & 105 Charging Machine: Material	Storage	Labor	Net Cost	Equiv $ Gain in Reactor Utilization	Associated Problems
Tube assembly to contain column of elements. Tubes grouped to form revolver action as ultimate part of new type charge machine.	$1.00	$3.33	$1.00	$14.33	$260-575 est gains, including influence of new equipment (but not cost of new machines)	Storage density so low as to suggest tube loading from option 1, 2, 4, or 6 at reactor work area. "Column charging" allows high average velocities. Element-deflectors at gear face allow total utilization gain of $390-705/unit.
Rod assemblies are sub-columns to be combined into continuous column. Sub-columns are suspended w/cable thru internal-cooling core. Sub-columns used in autoclave process at FPD & transported to IPD in same configuration. Cables are removed when sub-columns are tipped to horizontal position on roller conveyor. Fuel elements are then ready for either tube or roller conveyor sections using column-effect charging.	7.25	.82	2.00	10.07	[illegible] gain no greater than $390	Column-effect charging requires a special elevator or hoist in front area. Elevator quality determines working length of full column.

END

DATE
FILMED
5/20/93