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ACTINIDE RECYCLE

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WHAT ARE WE NOW TRYING TO DO?

In the Mid-80s, the United States Terminated the Development of Large LMFBRs, and Drawing on the LMFBR Technology Base, Initiated the Liquid Metal Reactor (LMR) Program Seeking Improved Safety, Reduced Costs, and Improved, Environmentally Acceptable, Fuel Cycle

WHAT IS ACTINIDE RECYCLE?

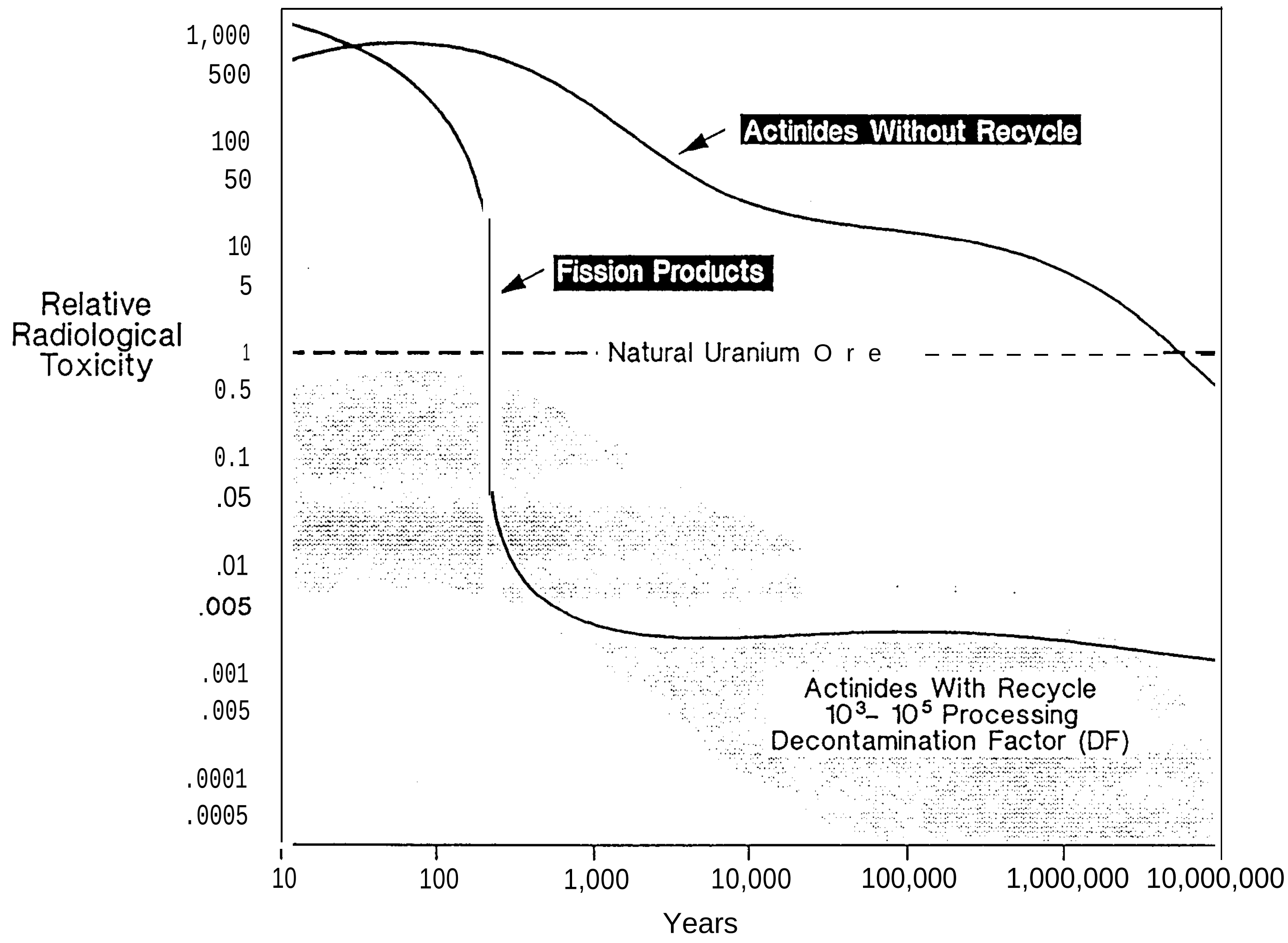
Actinide Recycle Refers to the Separation and Recycle of Plutonium and the “Minor” Actinides from Spent Fuel

Plutonium Recycle Refers to the Separation and Recyc e of Plutonium from Spent Fue

INTEREST IN ACTINIDE RECYCLING ARISES BECAUSE

- Extend Uranium Resources for Energy Production by Using Spent Nuclear Fuel
- Actinides are the Dominant Contributor to the Long-Term Toxicity of Buried Nuclear Waste
- Actinide Recycle can Ameliorate this Long-Term Toxicity
  - Avoids storing actinides "forever" by separating them from fission products and converting (transmuting) them in LMRs

RELATIVE TOXICITY OF SPENT FUEL



KEY FACTS

- The Radioactivity Toxicity Hazard of the Repository is Related to its Contents
- Processing the Waste to Recover and Burn the Actinides can Reduce Toxicity Concerns from a Million Years to Below that of the Source Uranium and its Daughter Products Within 200-300 Years
- Risks Due to Escape from the Repository are Pathway Dependent

  Volcanic explusion

  Public intrusion

  Gee-hydrological leaching of soluble, mobile constituents
- Processing the Remaining Fission Products can Significantly Reduce Mobility Concerns and Heat Loads that Must be Dealt with in a Repository

STATUS OF ACTINIDE RECYCLE TECHNOLOGY

- The IFR Metal Fuel Cycle is at an Early State of Development for Post 2010 Application
- Tasks are Underway to:

  Process demonstration of separation of actin des from FR spent fuel

  Fabrication of fuel assemblies containing reprocessed actinides

  Large volume recycle of refabricated fuel assemblies through the reactor

  Develop technology for reprocessing waste streams into environmentally acceptable forms

- Successful Development will Result in Waste from an Operating IFR System Which is Essentially Actinide Free
- Studies have been Started to Explore Extension of IFR Technology to LWR Spent Fuel ‘

INTEGRAL FAST REACTOR

WHAT IS THE INTEGRAL FAST REACTOR (IFR)?

- The IFR is a Generic Reactor System -- in the Same Sense as the LWR is a Generic Reactor System and Not a Specific Design. The General Electric PRISM Reactor is a Specific Design of an IFR Reactor

- The Entire Fast Reactor System -- Reactor, Fuel Cycle, and Waste Process is being Developed and Optimized at the Same Time as a Single “Integral” Entity

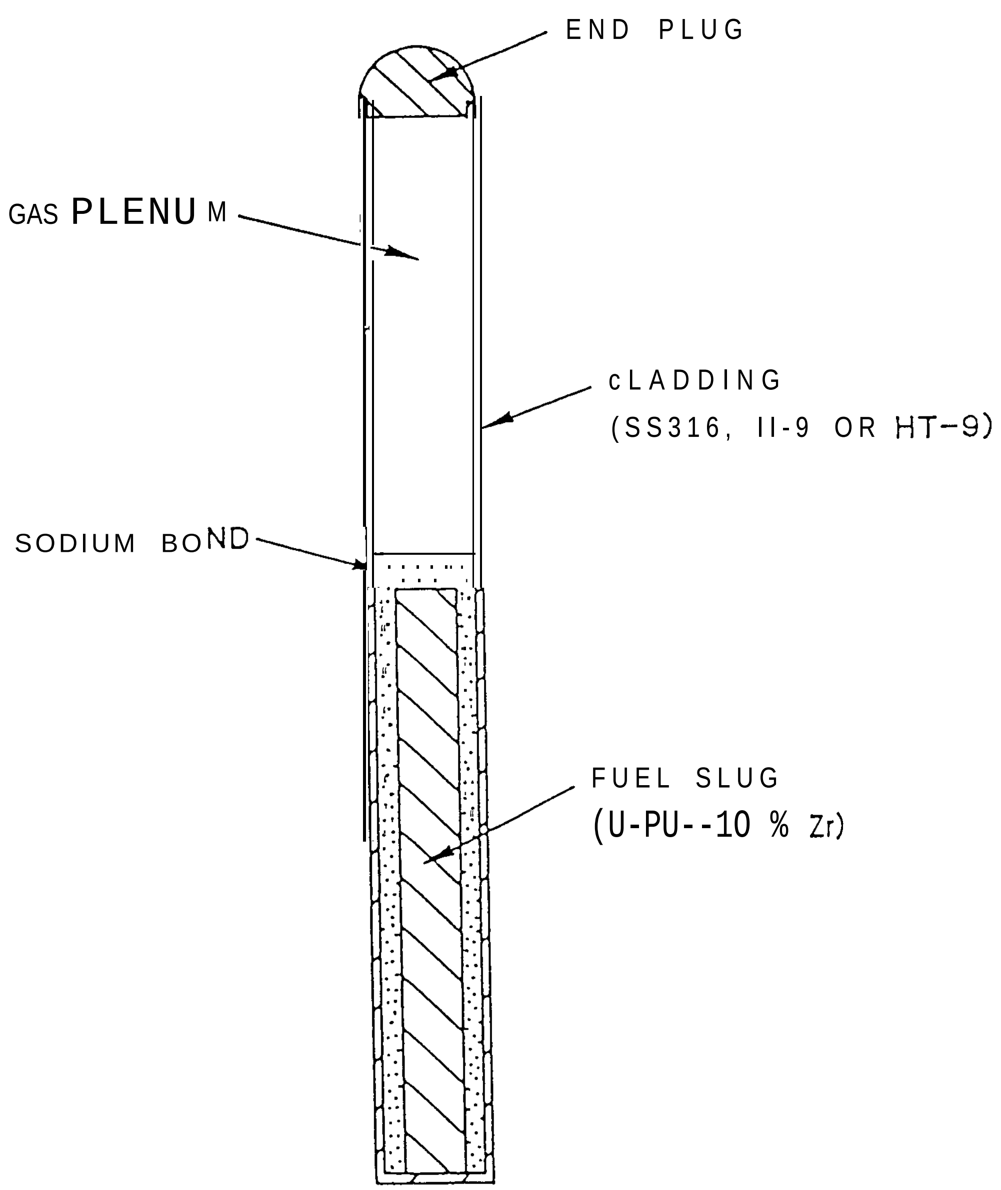
- The IFR is a “Closed” Fuel Cycle. [t Separates and Recycles Almost all the Actinides (Along With Some Rare Earths)

IFR PROGRAM ELEMENTS

- Metal Fuel Performance: Meta Fuel is the Foundat on of the IFR Concept
- Safety: Metal Fuel is Key to Ach eving Pass ve Safety
- Fuel Cycle: Most mportant Rationale for the IFR Concept
- PRISM Reactor: Passively Safe, Modular, Metal Fuel

Metal Fuel Performance

METALLIC FUEL ELEMENT



CLADDING O. D.	0.3 in.
FUEL SMEAR DENSITY	75 %
FUEL LENGTH	36 in.
PLENUM/FUEL RATIO	1.2
PEAK LINEAR POWER	15 kW/ft.

PERFORMANCE CHARACTERISTICS OF I FR ALLOYS NOW DEMONSTRATED BY IRRADIATION TESTS

- The Lead Tests on U-Pu-Zr and U-Zr Fuels have now Ach eved 185,000 MWd/T (1 8.5 At. %) Burnup, Far Exceeding The r Design Burnup Leve of 100,000 MWd/t (1 O At. %)

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- Extensive Test Matrix or Cladding Types, Des gn Variables, and Operating Conditions

- EBR-II is now Fully Converted with the IFR-Type Fuel Alloys (U-Zr and U-Pu-Zr)

- Complementary Tests in FFTF to Investigate Length Effects

IFR Safety Features

INHERENT PROPERTIES THAT LEAD TO MUCH SUPERIOR IFR SAFETY FEATURES

- Ample Margin Between Sodium Boiling Temperature (1650°F) and Operating Temperatures (650° F Inlet 950° F Outlet)
- Atmospheric-Pressure Primary System
- Large Thermal Inertia of Pool Configuration
- High Thermal Conductivity of Metal Fuel Results in a Low Fuel Temperature: Less Stored Energy and Less Stored Doppler Reactivity

IFR SAFETY POTENTIAL DRAMATICALLY DEMONSTRATED IN EBR-II

- On April 3, 1986 Two Landmark Demonstrations were Conducted at EBR-II
  - Loss of flow without SCRAM from full power
  - Loss of heat sink without SCRAM from full power

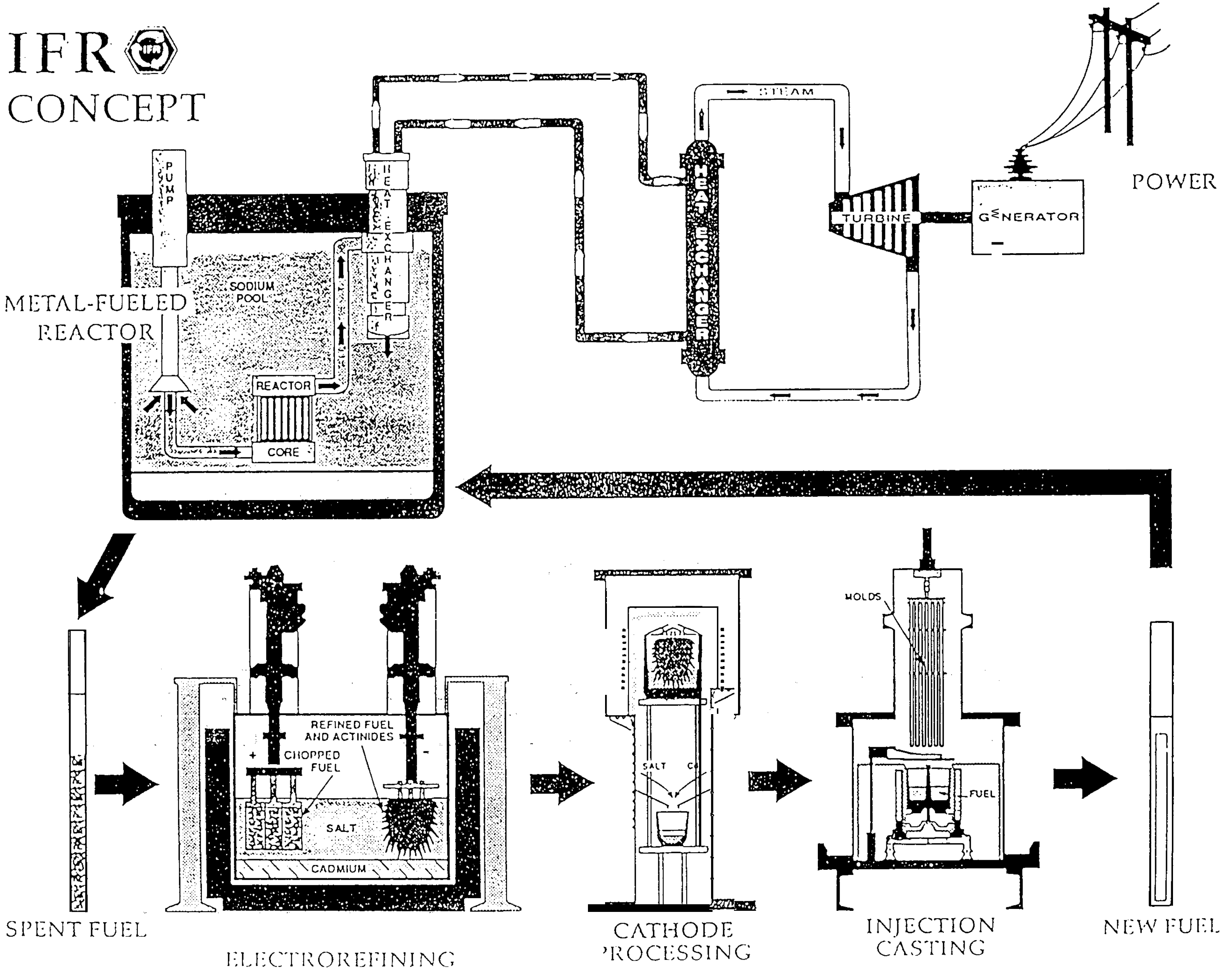
IFR Fuel Cycle

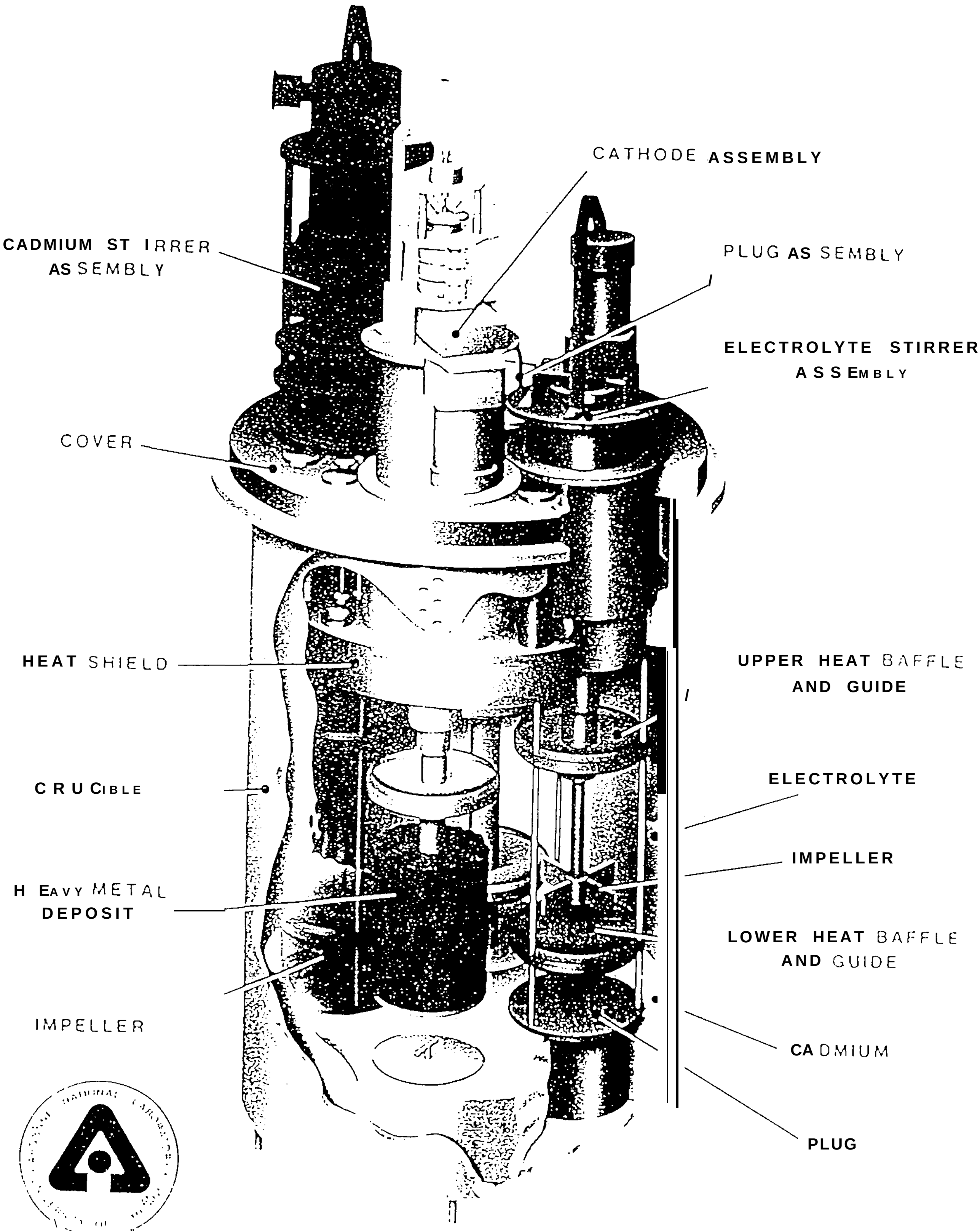
METAL FUEL FABRICATION IS VERY EASY

- Injection Casting
- Simple Operation, Low Cost
- Does Not Require Tight Specifications

THE IFR METAL FUEL CYCLE INVOLVES ONLY A FEW COMPACT BATCH OPERATIONS

- Spent Fuel Pin Chopping
- Electrorefining
- Cathode Processing
- Injection Casting
- Pin Processing and Assembly

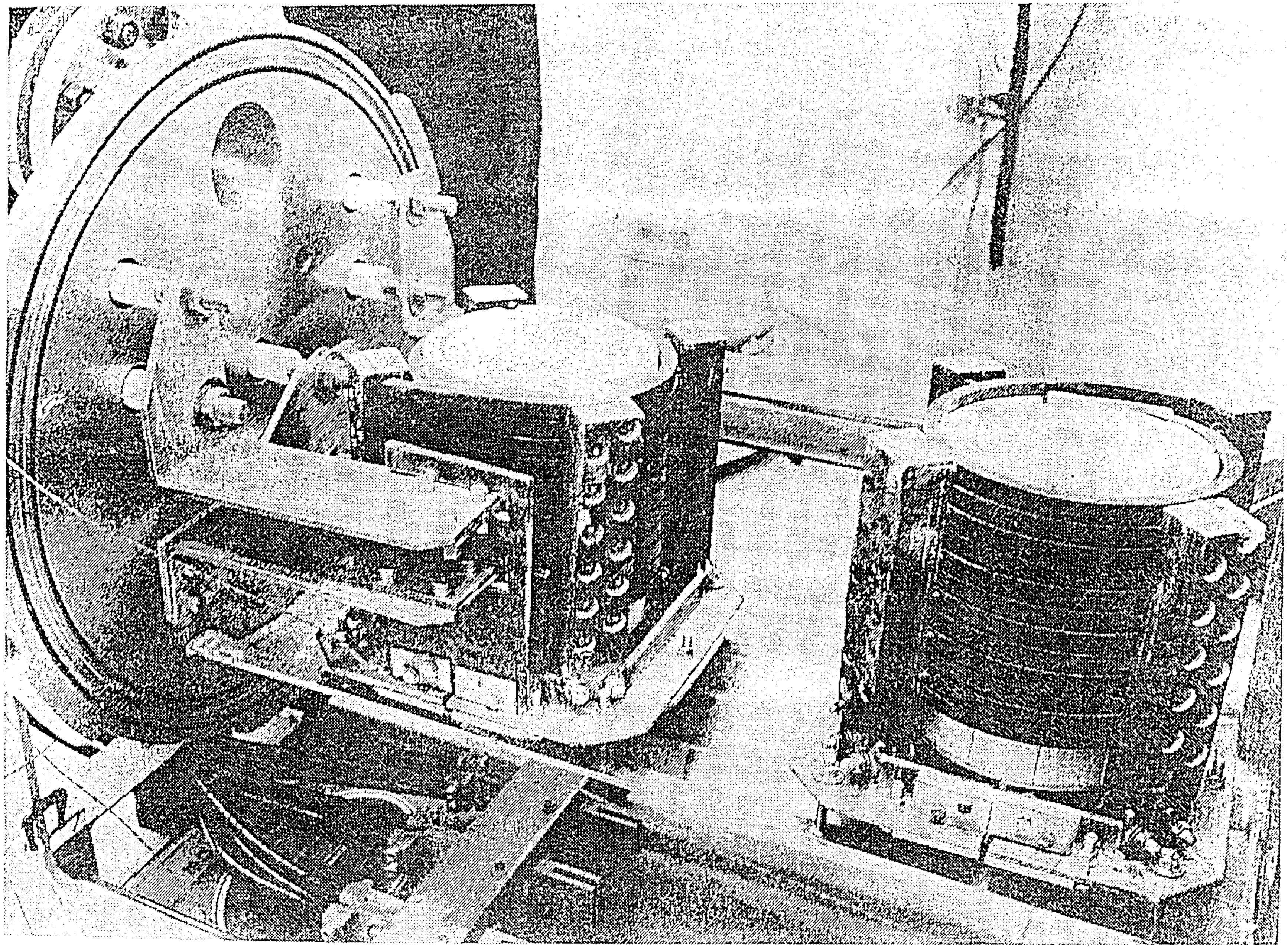

IFR
CONCEPT
METAL-FUELED REACTOR
PUMP
SODIUM POOL
REACTOR
CORE
HEAT EXCHANGER
STEAM
TURBINE
GENERATOR
POWER
SPENT FUEL
REFINED FUEL AND ACTINIDES
CHOPPED FUEL
SALT
CADMIUM
ELECTROREFINING
SALT
CATHODE PROCESSING
MOLDS
FUEL
INJECTION CASTING
NEW FUEL



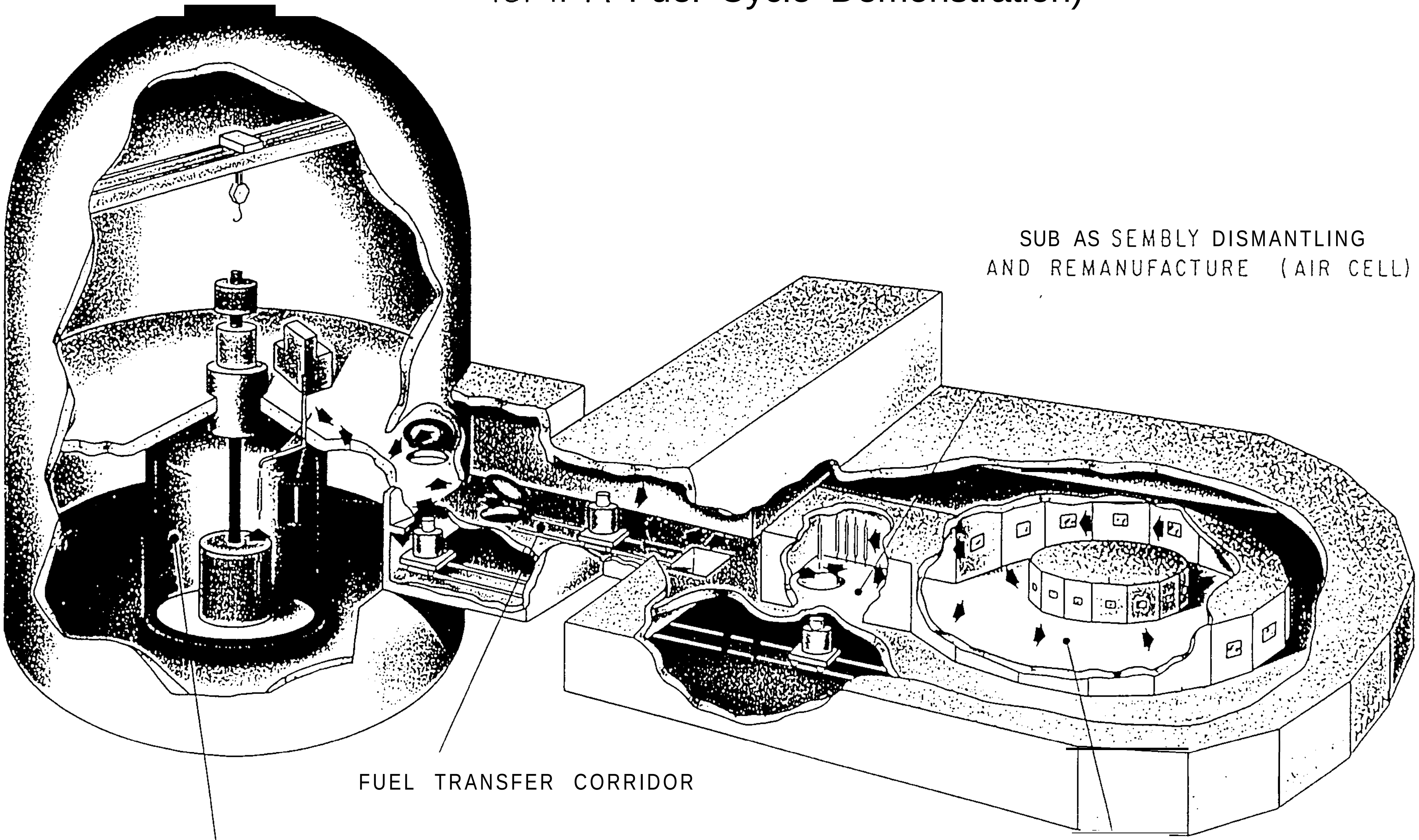
IFR ELECTROREFINER

(3” diameter, 4’ height)

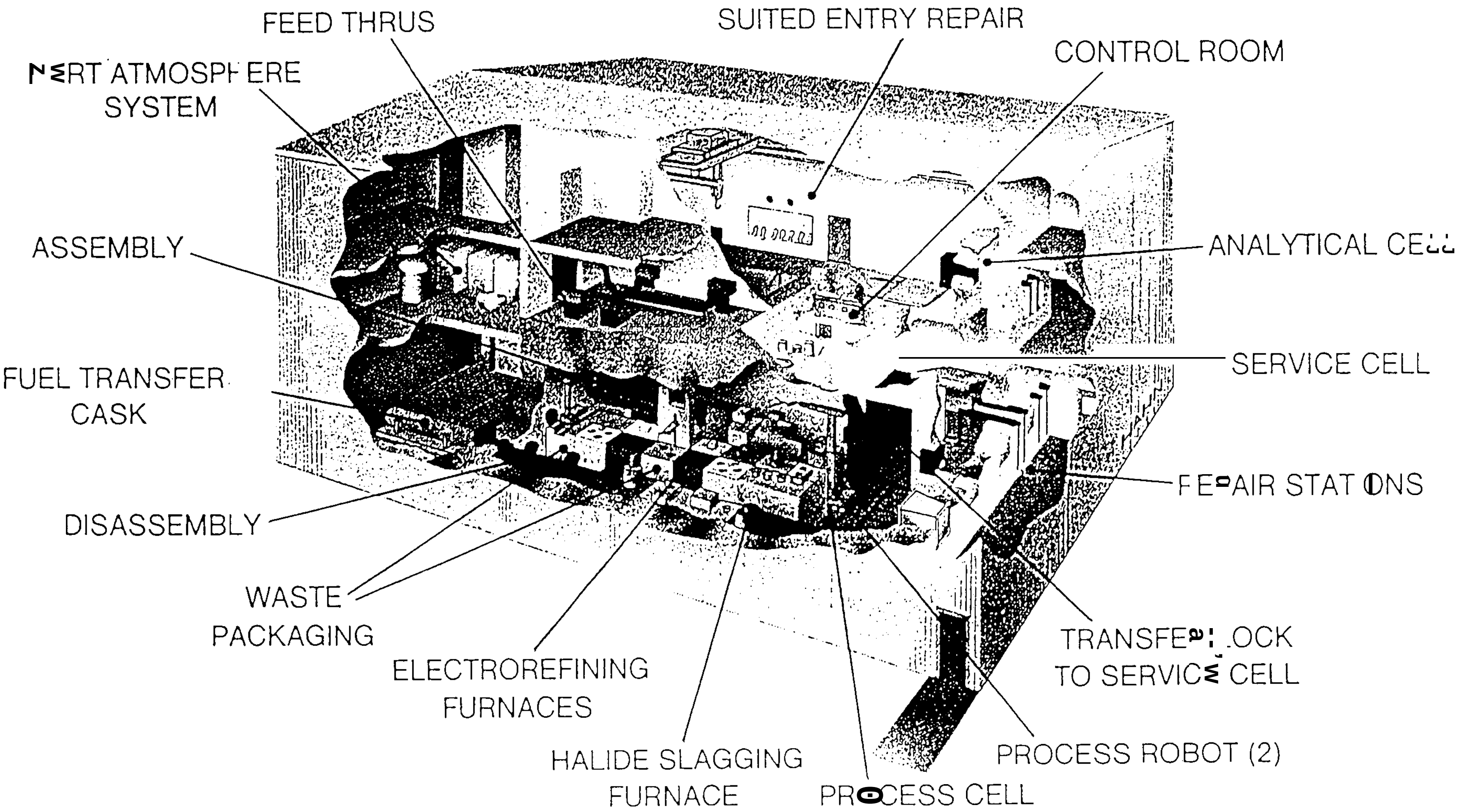
DUEL INJECTION CASTING CRUCIBLES IN EBR-II FUEL MANUFACTURING FACILITY CAN HANDLE UP TO 1400 MWe THROUGHPUT



EBR-II REACTOR AND FUEL CYCLE FACILITY
(Fuel Cycle Facility Now Under Modification for IFR Fuel Cycle Demonstration)



Commercial Scale IFR Fuel Cycle Facility



THE IFR METAL FUEL SHOULD NOT BE READILY WEAPONS USEABLE

. Similar ties in Electrochemical Properties of Uranium, Plutoni ım, Minor Actinides (e.g., Np, Am, Cm) and Lanthanides (e.g., Nd, Ce, La) S ıould Make it Virtua ly Impossible to Achieve Complete Separation of these Elements

Plutonium and minor actinides co-deposit with approximately equal amounts of (mostly non-fissile) uranium

10-20% of the lanthanide content follows with the uranium/actinide product

- Result if a Product Fuel Form Which Must be Handled Remotely Due to Radiation Levels from Minor Actinides and Lanthanides; these Radiation Levels are Approximately Equal to those Associated With LWR Spent Fuel that has Cooled for 10 Years

THE KEY NEXT STEP IN IFR FUEL CYCLE DEVELOPMENT

- Prototype Demonstration of the Entire IFR Fuel Cycle
- Necessary Facilities Will be in Place by September 199
- Fuel Cycle Demonstration Scheduled to be Completed by 1995

The ALMR Reactor Plant - PRISM

PRISM CONCEPT DEVELOPMENT

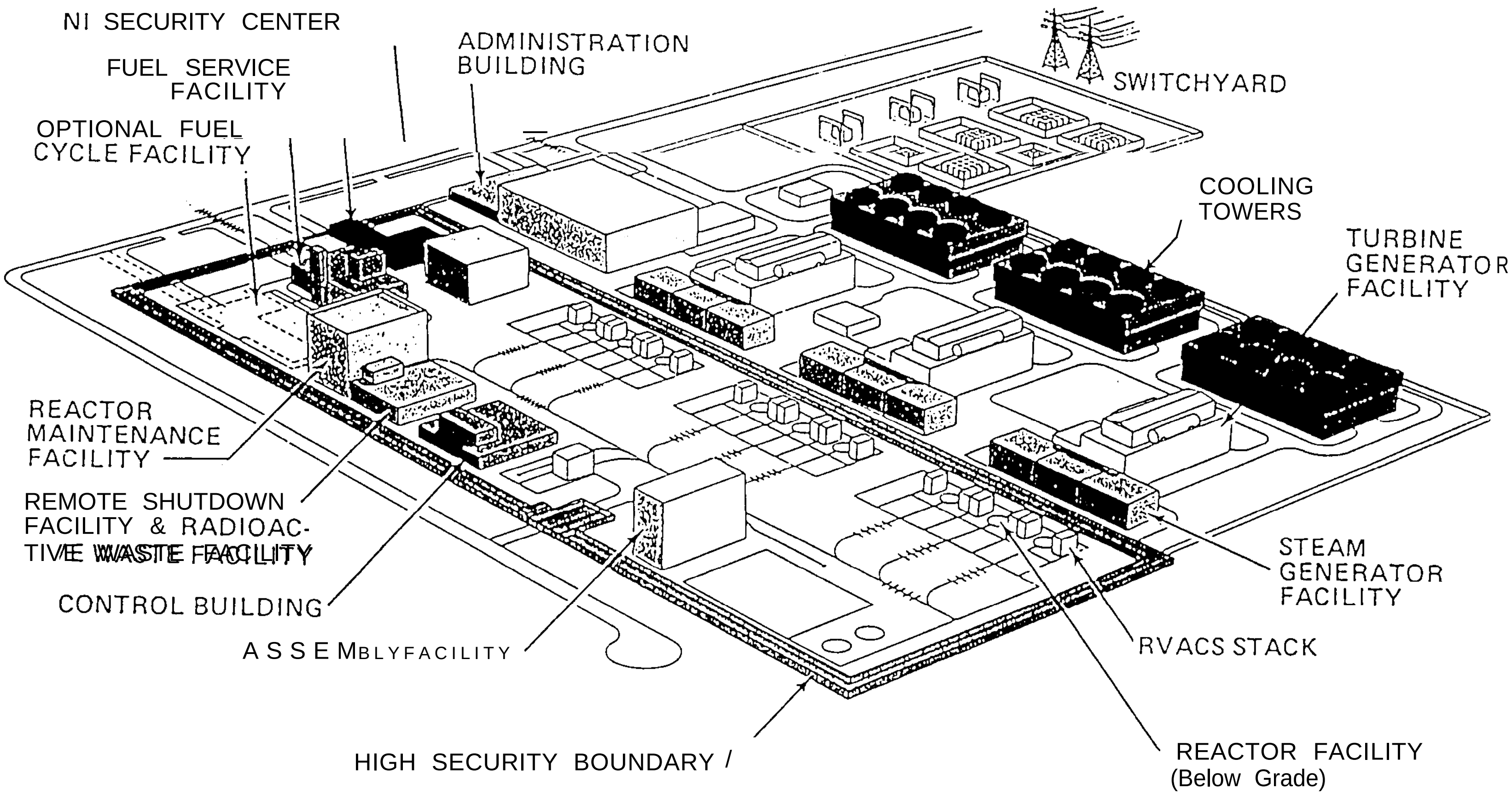
Phase 1

- 3-Year Program
  - Establish licensable conceptual design

Phase 2

- 2-Year Program
  - Complete preliminary design
  - Obtain private sector commitment

ALMR Power Plant (3 Power Blocks) -1395 MWe



LWR ACTINIDE RECYCLE

U.S. DOE LWR ACTINIDE RECYCLE INITIATIVE GOALS

- Creation of a Synergistic LWR/LMR/Reprocessing/Waste Management System that Will Help to:

  Extend uranium resources for energy production by using spent nuclear fuel

  Reduce the amount of hazardous actinides to be placed in a geologic repository

  Extend capacity of the repository

  Enhance public acceptance of nuclear power

  Source of startup fuel for LMRs

PYROCHEMICAL PROCESSING

- A Preliminary Assessment has been Made of the Feasibility of Using Pyrochemical Processes for Extracting Actinides from LWR Spent Fuel

  Start from technology developed at ANL in the 1960s for processing EBR-II metal fuel and mixed oxide fuel

  Two promising pyroprocess flowsheets have been identified

  Actinide product and waste streams are similar to IFR streams

  -- No actinide/lanthanide separation should occur

  Initiation of development program in FY91

IMPLICATIONS OF ACTINIDE RECYCLE ON WASTE REPOSITORIES

- Successful Development of Actinide Recycle for LWR Spent Fuel will not Obviate the Need for a Deep Geologic Repository Since There will be:
  - Some civilian high level waste and small quantities on non-LWR generated high level waste
  - Some solidified defense waste containing some actinides
- In Conjunction with other Nuclear Waste Management Activities, Further Actinide Burnup R&D has the Potential to Minimize the Amount of Waste that Must be Placed in a Repository
- The Need for a Second Repository Could be Significantly Delayed or Eliminated if Regulations can be Appropriately Modified to Benefit from Actinide Removal and Other Waste Management R&D

ACTINIDE RECYCLE RAMIFICATIONS

- Requires a Change from a Once-Through Fue Cycle to a Reprocessing Cycle
- Actinide Recycle Can be Used as an Excuse to Delay or Stop the Repository Program
- A Spent Fue Reprocessing Facility Must be Licensed and Sited
- LMRs Must be Licensed and Deployed Along With their Fuel Cycle Facilities
- Requires Transportat on of H ghly Radioactive Fuel for LMRs
- Adds a Cost Increment Over and Beyond LWR Fuel Disposal Costs Which Will be Included in the LMR Fuel Cost
- Requires Substantial Capital Investment