FZM-1802
May 6, 1959

FISSION PRODUCT DISPERSAL EXPERIMENT

SERIES II

- Experiment Design -

Convair
A DIVISION OF GENERAL DYNAMICS CORPORATION
FORT WORTH

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B of F approval conditional
for material

INTRODUCTION

As part of the USAF-AEC Safety Program for Nuclear Aircraft, a fission product field release test will be conducted at Dugway Proving Ground, Utah, during the summer of 1959. The test series is under the sponsorship of the Air Force Special Weapons Center of the USAF Air Research and Development Command. Convair-Fort Worth will serve as Test Director and make dispersal measurements. The University of Rochester will conduct biological experiments. Fuel elements and effluent radiochemical analysis will be furnished by the Aircraft Nuclear Propulsion Department of General Electric. AFSWC and Army Chemical Corps will provide test support.

This report outlines the principal features of the test series.

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The purpose of this series of tests is to study the long-range dispersal characteristics of fission products under strong inversion conditions. The method of release will simulate the most probable mechanism to be encountered in a nuclear aircraft accident, namely meltdown.

The sampling network will extend 20 miles from the release point to provide data at distances of interest for nuclear aircraft accidents which occur under stable or nighttime conditions.

Animals will be exposed to the fission product activity in an effort to simulate the uptake of the human respiratory system and retention in critical organs.

The heat from a large aircraft fuel fire may significantly decrease activity levels near the ground by lofting the effluent above the low level stable air. The effect of this mechanism on the dispersal of the fission product activity will be determined.

TEST OBJECTIVES

- TO DETERMINE THE RELEASE, AIRBORNE ACTIVITY, AND GROUND DEPOSITION OF SELECT FISSION PRODUCTS FROM MELTDOWN OF ANP-TYPE FUEL ELEMENTS UNDER STRONG INVERSION CONDITIONS OUT TO A DISTANCE OF 20 MILES.

- TO DETERMINE THE INHALED ACTIVITY IN DOGS EXPOSED TO THE RELEASED FISSION PRODUCTS AND THE SUBSEQUENT BIOLOGICAL DISTRIBUTION.

- TO DETERMINE THE EFFECTS OF AIRCRAFT FIRE ON THE DISPERSAL OF FISSION PRODUCTS.

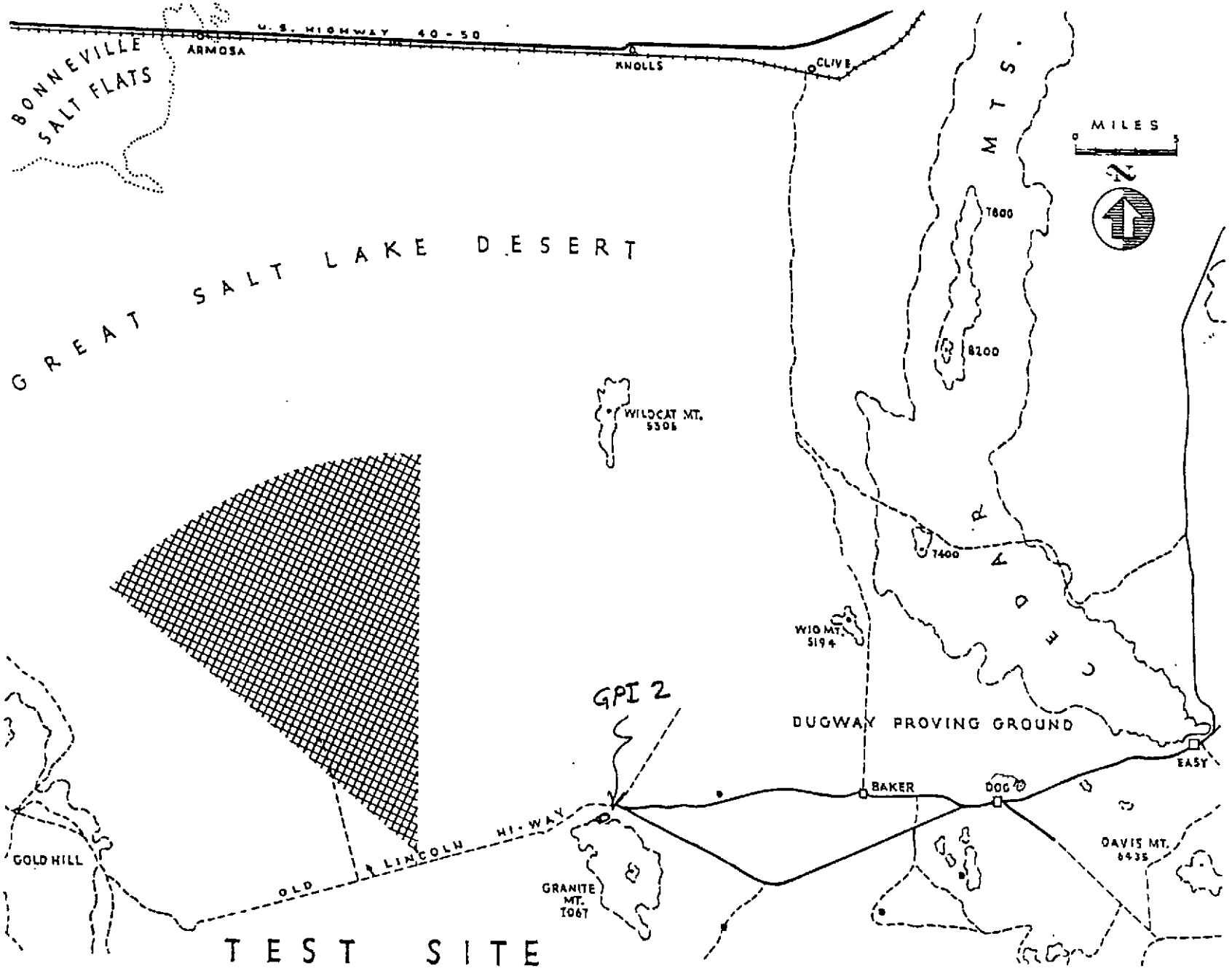
This test series will consist of a total of nine releases. Each release will be made using a segment of a freshly irradiated aircraft-type fuel element in a shielded induction furnace. Six releases will be made to the atmsophere during two of which animals will be exposed. Two releases will be accompanied by a large aircraft fuel fire. One release will be made with a completely enclosed system, wherein all the effluent will be retained for analysis. Consideration is being given to two additional enclosed melts if funds become available.

The first fuel element specimen will be melted approximately two weeks after removal from the MTR, at which time the I^{131} activity will be about 100 curies. The first release will be in mid-July.

TEST SERIES

Release Number	Condition
1 - 4	Release to Atmosphere
5 - 6	Release to Atmosphere - Animals Exposed
7 - 8	Release to Atmosphere - JP-4 Fire
9 - 10 - 11	Enclosed System

The release site is situated on the Great Salt Lake Desert within the Dugway Proving Ground test area. The release point is located just north of the old Lincoln Highway about 12 miles west of Granite Peak (staging area) and 35 miles from Easy Area, Dugway entrance and housing area. The sampling network will consist of a 60°, fan-shaped grid with the centerline bearing 330°. This is in the direction of the most probable nighttime wind during summertime inversion conditions. The test area is composed of salt flats and silty clay flats with virtually no vegetation. There are no personnel other than those connected with the test within 20 miles of the release point. The nearest inhabited location downwind from the release site is 40 miles away.

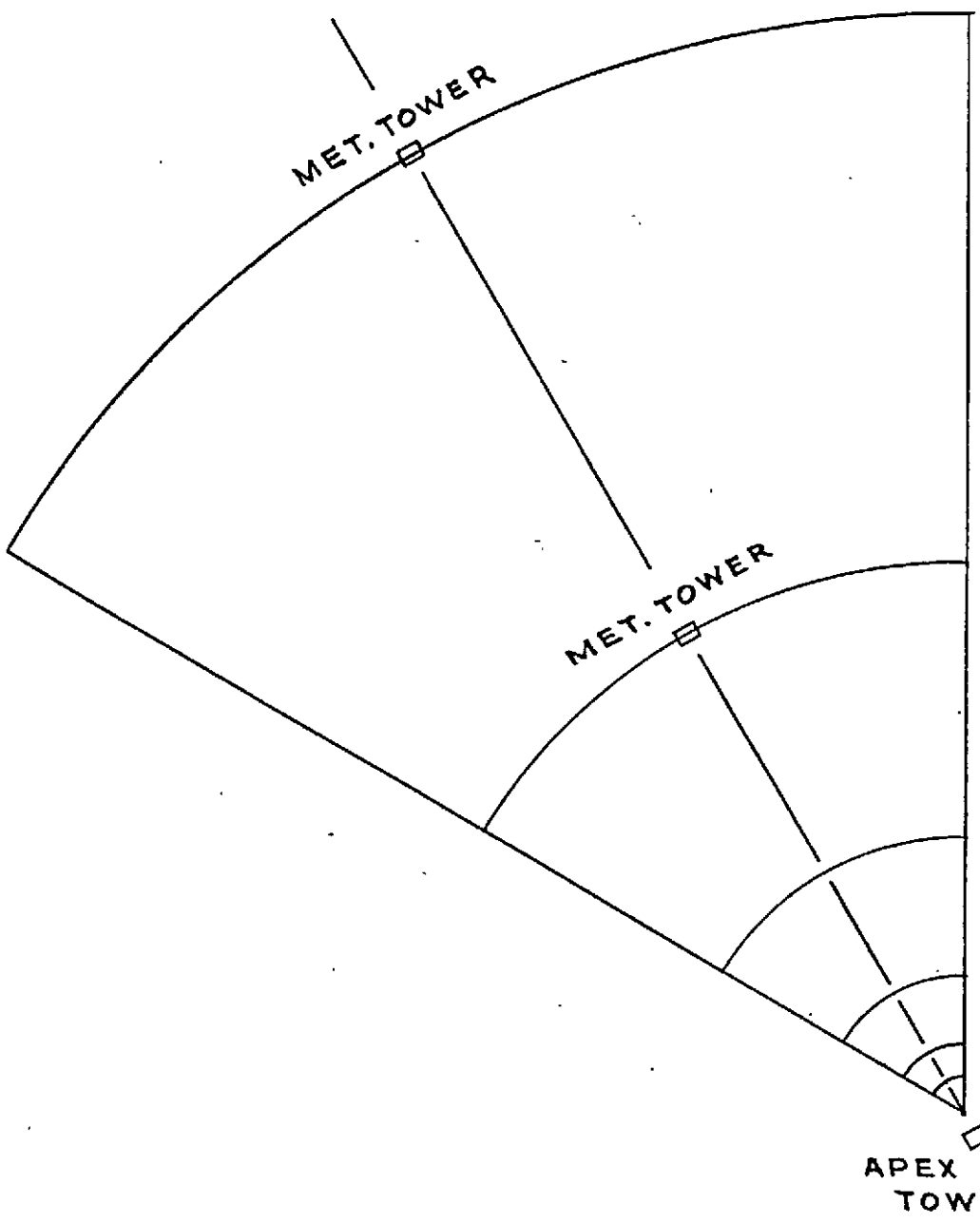

U.S. HIGHWAY 40 - 50
ARMOSA
KNOLLS
CLIVE
BONNEVILLE SALT FLATS
GREAT SALT LAKE DESERT
MTS.
MILES
0
5
N
7800
8200
7400
WILDCAT MT. 5306
W10 MT. 5194
GPI 2
DUGWAY PROVING GROUND
EASY
BAKER
DOG
DAVIS MT. 6435
GOLD HILL
OLD LINCOLN HI-WAY
GRANITE MT. 7067
TEST SITE

The test grid will consist of six instrumented arcs, spaced at equal logarithmic intervals, from 1 kilometer to 32 kilometers from the release point. High volume air sampling equipment (12 cfm) fitted with fiberglass filters and backed with activated charcoal cartridges will be placed on the two outer arcs. The four innermost arcs will be equipped with low volume samplers (1 cfm) using millipore filters backed with activated charcoal cartridges. The filters are for the collection of fission product aerosols, while the charcoal cartridge retains the gaseous iodine penetrating the pre-filter.

Fallout activity will be collected on three different materials. Two of these collectors, sticky paper and grass plots, will be placed in the test grid, while the third will be native soil samples. Sticky paper will be placed at 25 meters and on the 1, 4, 16, and 32-km arcs at each air sampler station for the first release and at 25 meters and on the innermost arc for all subsequent releases. The grass plots will be placed on the 1, 4, 16, and 32-km arcs for the first release only. During the first two releases native soil samples will be taken on each arc, at the three air sampler locations indicating the highest level of activity.

Collectively these samplers will provide data regarding integrated air concentration, and deposition as a function of distance downwind from the release point.

SAMPLING NETWORK



ARC DISTANCE	AIR SAMPLER SPACING	NO. OF AIR SAMPLERS
32KM	½°	121
16KM	1°	61
8KM	1°	61
4KM	1°	61
2KM	1°	61
1KM	2°	31

The sampling network will be equipped with meteorological instrumentation for measuring and recording the conditions which exist before, during, and after each release. Three towers will be instrumented for recording temperature and relative humidity at eight levels, windspeed at six levels, and wind direction at three levels. Each of the eight temperature measuring levels will be equipped with both wet and dry thermocouples. At each level one of the dry thermocouples will be paired with a dry thermocouple at the next higher level to give temperature difference between levels. A second dry thermocouple will be paired with a dry thermocouple on the next lower level for the same purpose. The remaining dry thermocouple will be coupled with a wet thermocouple at its own level for determining relative humidity. A trailer with appropriate recording instrumentation will be positioned at each met tower location. In addition, the apex tower will be equipped with instrumentation for measuring the air-to-ground heat transfer.

Since it is desired to make releases under the strongest inversions possible, tests will be performed on clear nights. Wind directions from 135° to 165° will be acceptable with wind speeds between 2 and 6 meters/sec. The lower wind speed is that which will carry the effluent past the ~~20~~ 32 km arc within a reasonable time before the inversion breaks. All releases will be subject to strict meteorological control and will be based on forecasts from the Dugway weather office and the Convair meteorological control station. Existing Dugway stations at Blackrock and Callao will be used to forecast favorable release conditions.

METEOROLOGICAL NETWORK

- THREE - 32 METER TOWERS ON CENTERLINE AT APEX (-0.1 KM), 16 KM and 32 KM ARCS

  3 DRY THERMOCOUPLES
  1 WET THERMOCOUPLE — 0.25, 0.5, 1, 2, 4, 8, 16, and 32 METERS

  2 DRY THERMOCOUPLES AT -3, -6, -12, and -100 CM

  ANEMOMETER AT 1, 2, 4, 8, 16, and 32 METERS

  WINDVANE AT 2, 8, and 32 METERS

- FIELD UNIT (3 METER HEIGHT) ON CENTERLINE AT 2 KM WITH WINDVANE AND ANEMOMETER

- TWO UPWIND METEOROLOGICAL STATIONS AT BLACKROCK AND CALLAO

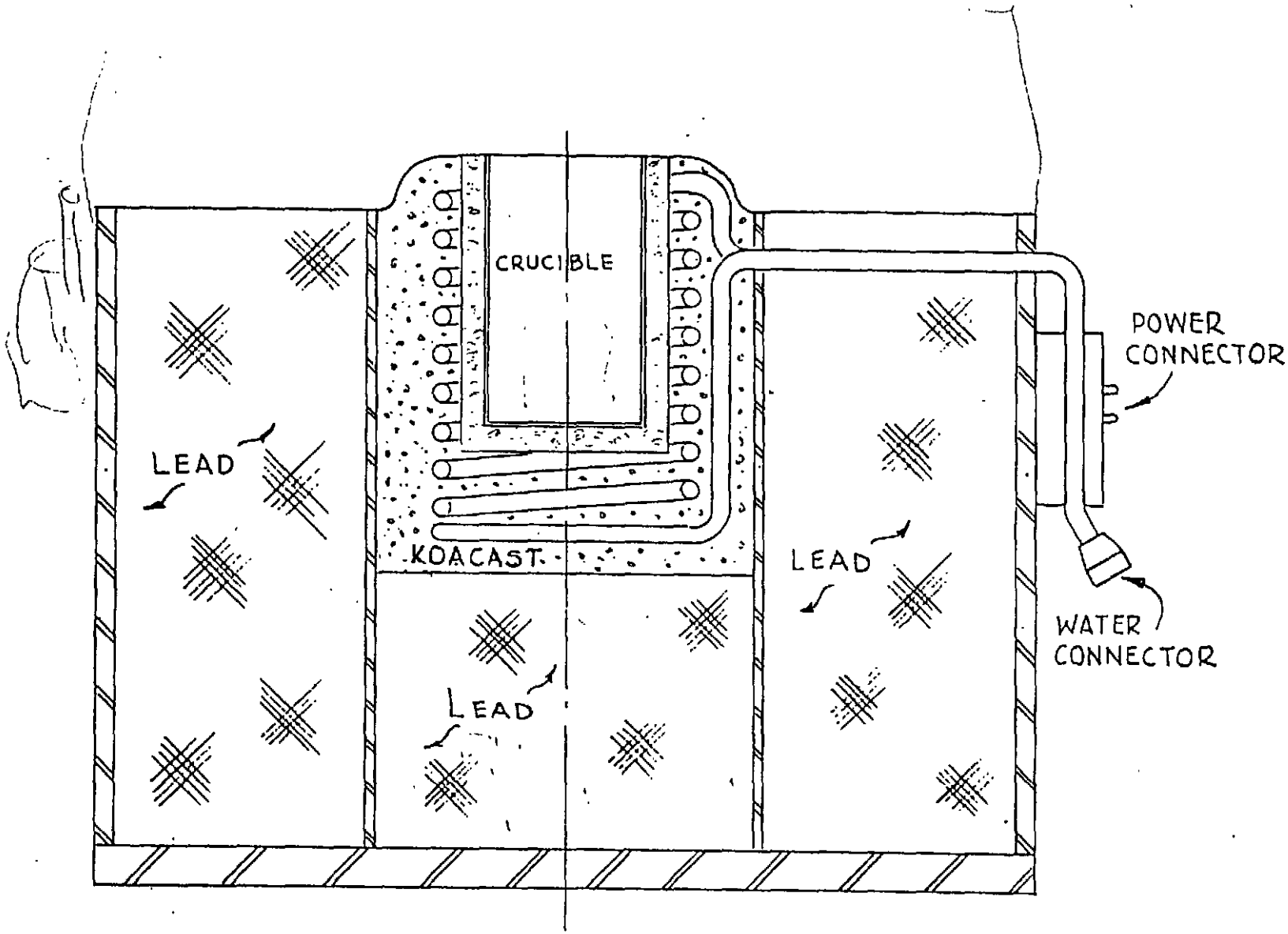
- RADIATION INSTRUMENTATION AT APEX TOWER

  RADIOMETER

  PYRHELIOMETER

  HEAT FLUX PLATE

Each fuel element sample will be melted in a specially constructed, combination shielded shipping cask and induction furnace. Each fuel element sample will be transported and melted in a separate furnace, and the furnaces will be disposed of following the melts. The sample will be held in a mullite-lined graphite crucible surrounded by an induction coil which is coupled to a 10-kilocycle, 60-kw induction power supply The furnace is equipped with a thermocouple and an air supply line for purging the effluent from the curcible. Direct effluent sampling is accomplished by means of a tube which extends into the top of the curcible from a filter system. Each furnace will be loaded at the GE Idaho Test Station hot cell and transported by truck to a release site at Dugway Proving Ground. The furnace casks are designed such that a contact gamma dose rate is $\leq$ 200 mr/hr at 2 weeks after sample irradiation.



INDUCTION FURNACE

Arrangements have been made with GE-ANPD for three 5-day irradiation cycles in the MTR. The first fuel element assembly to be irradiated will contain three stages; the second, four stages; and the third, five stages. Irradiation periods will end June 29, July 20, and August 10, 1959. Following each irradiation period the stages will be separated in the GE hot cell, loaded in separate furnace casks, transported to the release site, and melted in successive releases. Transportation from NRTS to the test site will be provided by Dugway. Accountability as well as responsibility for disposal of cask with residue will be assumed by Dugway. Burial will be at NRTS.

Fission product inventories have been calculated for the five-day irradiation followed by two weeks of decay. This is the activity expected for the first release in each of the three batches. Based on previous experiments at the National Reactor Test Station in the summer of 1958, the expected isotopic releases have also been calculated.

Dose rate at ten feet from a bare sample would be about 50 Rem/hr. However, the seven inches of lead shielding will lower the dose rate to 0.2 Rem/hr at the cask surface.

FISSION PRODUCT RELEASE

(FRESHLY IRRADIATED 1-M-B ASSEMBLY)

ISOTOPE	INVENTORY (CURIES)	RELEASE %	RELEASE (CURIES)
Bone Seekers			
Sr^{89}	80	2	1.6
Sr^{90}	0.6	2	.012
Zr^{95}	90	0.5	.45
Ce^{141}	135	0.6	.8
Ba^{140} La^{140}	200	1	2
Thyroid Seeker			
I^{131}	100	50	50
Kidney Seeker			
Ru^{103}	60	4	2.4
Muscle Seeker			
Cs^{137}	0.5	83	.42
External Dose			
Xe^{131m}	1	100	1
Xe^{133}	150	100	150

Samples of the furnace effluent from each release and the effluent from the enclosed release will be taken to NRTS for radiochemical analysis. GE Idaho Test Station will perform radiochemical analysis of a portion of certain test stages to determine the pre-release inventory of select products.

Network filters and fallout samples will be sent to Fort Worth for gamma spectral analysis and radiochemical analysis. These samples will be counted on a scintillation spectrometer arranged to provide direct counts from the four prominent activities expected, i.e., iodine-131, cesium-137, ruthenium-103, and zirconium-95. Counts will be taken at several times after the release to verify identification and decay corrections. Select samples will be counted on a 256-channel gamma spectrometer for other activities.

SAMPLE ANALYSIS

	GAMMA SPECTROMETRY	CHEMISTRY
PORTION OF ELEMENT	--	I, Cs, Ru, Zr, Ce, Ba, Sr
FURNACE EFFLUENT	--	I, Cs, Ru, Zr, Ce, Ba, Sr
NETWORK FILTERS	I, Cs, Ru, Zr, Ce, Ba	Sr
FALLOUT SAMPLES	I, Cs, Ru, Zr, Ce, Ba	Sr

Investigation of the uptake and metabolism of the fission products will be conducted by the University of Rochester. Dogs will be placed downwind of the release point at a distance yet to be determined. The animals (approximately 25) will be placed on a movable stand such that they can be positioned within the expected cloud path. Air sampling equipment will be placed at the animal location to determine the integral air concentration and to estimate the particle size distribution of the fission product activity.

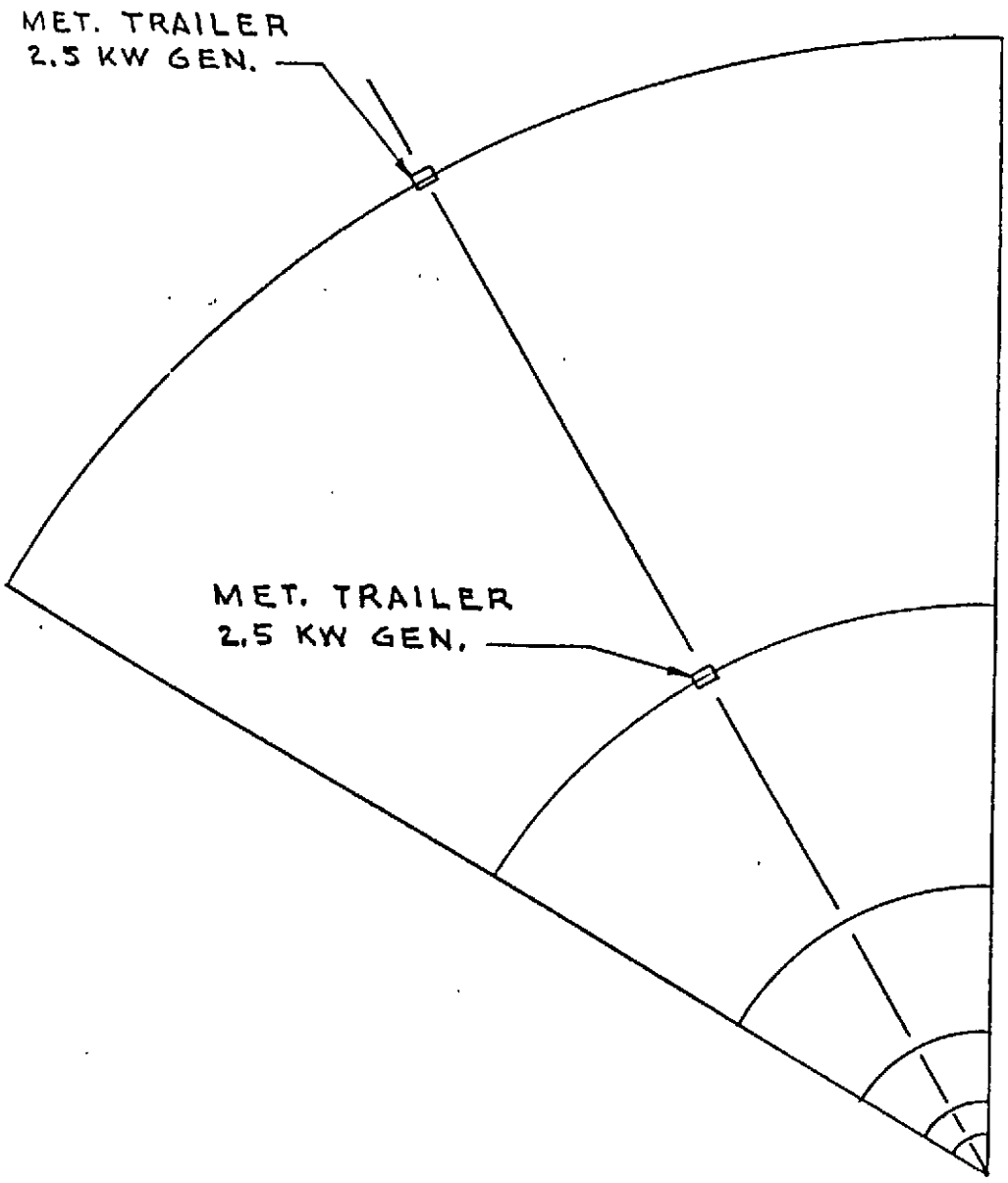
Following each release, the dogs will be scanned and certain animals sacrificed, autopsied and various organs and tissues removed for analysis. Select animals will not be sacrificed immediately but will be retained for metabolism studies over extended periods.

ANIMAL EXPERIMENTS

- DOGS BETWEEN 1 KM ARC AND RELEASE POINT
- EXPOSURES MADE DURING TWO RELEASES
- AIR AND PARTICLE SAMPLERS AT ANIMAL LOCATION
- CORRELATION OF FISSION PRODUCT AIR ACTIVITY WITH UPTAKE, DISTRIBUTION, AND EXCRETION

Due to the remoteness of the test site, all electrical power requirements will be supplied by motor-generator sets. The disposition of generators is shown on the opposite page. The inner three arcs will be wired such that the air samplers may be turned on from the apex control point. Lights will be placed on all generators on the outer arcs to facilitate night operations.

POWER DISTRIBUTION SYSTEM



32KM 3KW GEN. EACH STATION (121)

16KM 2.5 KW GEN. EACH STA. (61)

8KM 2.5 KW GEN. EACH STA. (61)

4KM FIVE 5 KW GEN.

2KM THREE 7.5 KW GEN.
1KM TWO 10KW GEN.

□ □ CONTROL
TWO 15 KW GEN.
ONE 25 KW GEN.

Site preparations, including installation of equipment, will be accomplished as a joint effort by Dugway, AFSWC, and Convair.

The various support services required for successful completion of the test series will be provided primarily by Dugway and AFSWC with the exception of Health Physics monitoring which will be accomplished by Convair.

SITE PREPARATION AND SUPPORT SERVICES

- SURVEYING AND STAKING OF SAMPLING GRID (DUGWAY)
- SAMPLING EQUIPMENT PREPARATION AND INSTALLATION (CONVAIR AFSWC)
- METEOROLOGICAL TOWER ERECTION (DUGWAY)
- POWER DISTRIBUTION (CONVAIR AFSWC)
- WEATHER FORECASTING (DUGWAY)
- HEALTH PHYSICS (CONVAIR)
- VEHICLES FOR EQUIPMENT AND PERSONNEL (AFSWC DUGWAY)
- VEHICLE SERVICING (DUGWAY)
- FUEL ELEMENT ACCOUNTABILITY (DUGWAY)

All personnel participating in the release tests will be governed by radiation and contamination controls established by Convair Health Physics personnel. Entry into and exit from the test area of personnel, vehicles, and equipment will be made at a designated location in order to maintain close surveillance for radiation exposures and contamination. Personnel entering the test area will be provided with anti-contamination clothing, respirators, film badges, and direct-reading pocket dosimeters. Monitoring equipment will be provided at the entry point.

Pre- and Post-test urinanalyses will be performed to assure the effectiveness of the measures taken to prevent inhalation exposures. Special analyses will be performed if an inhalation exposure is suspected.

Laundry of anti-contamination clothing will be performed by the Phillip's Petroleum Company at the National Reactor Testing Station.

RADIOLOGICAL SAFETY

- TEST AREA ENTRY AT DESIGNATED POINTS
- MONITORING CONTROL OF PERSONNEL, WORK AREAS, VEHICLES, AND EQUIPMENT
- PROTECTIVE EQUIPMENT
  - FILM BADGES
  - POCKET DOSIMETERS
  - ANTI-CONTAMINATION CLOTHING
- PRE- AND POST-TEST URINALYSIS
- RADIATION EXPOSURE HELD TO LABORATORY TOLERANCES

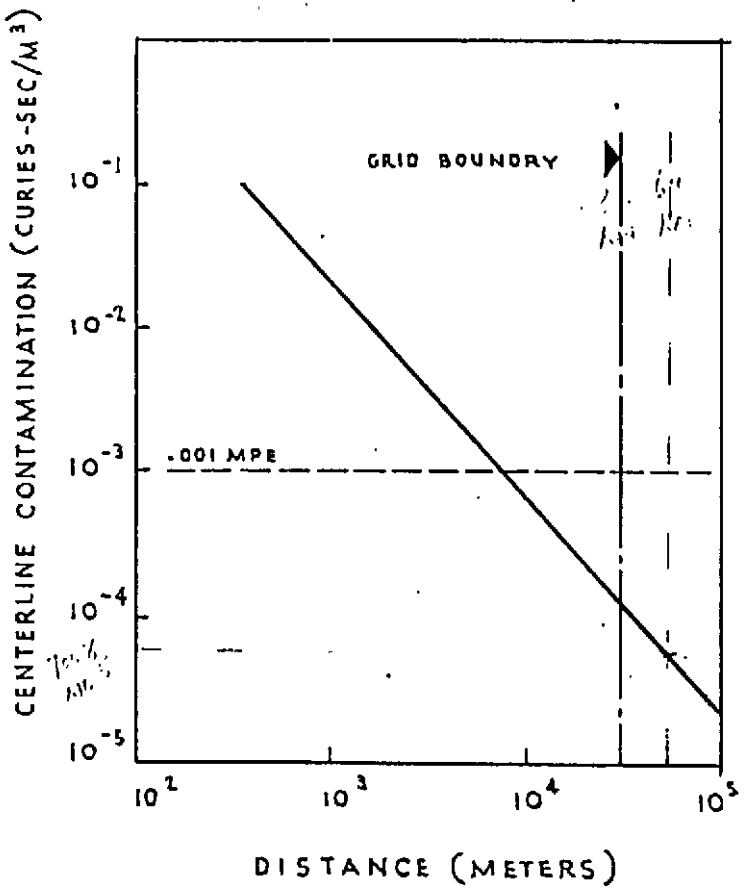
The principal airborne activity will be iodine-131. Approximately 50 curies will be released if the melt is made two weeks after the fuel element irradiation. Subsequent releases within a batch of elements will be made at about one-week intervals, close to the half-life of I-131. The expected airborne iodine concentration at the end of the sampling network (20 miles) is such that a person, standing in the centerline of the cloud and breathing the effluent during its entire passage, would receive a thyroid exposure of 0.001 MPE. This is based on a Maximum Permissible Exposure (MPE) of 400 Rem, which is thought to be equivalent to a whole body exposure of 25 Rem. Beyond the network and before reaching U.S. Highway 40, which is 40 miles from the release point, improved diffusion is expected due to solar heating on the following morning. Cs-137 concentrations are expected to be about a factor of a hundred less than iodine concentrations.

The principal deposited activity will also be iodine-131. The Maximum Permissible Concentration (MPC) for pasture is 2×10^{-3} μ curies/square meter based on milk contamination through the grass-cow-milk cycle. This level would occur between the end of the network and U.S. Highway 40. However, this criterion is extremely conservative, as there is no edible vegetation.

After the first release, data will be reviewed to assure that airborne and deposited activities at the end of the network are as low as expected.

DOWNWIND ACTIVITY LEVELS
(FIRST RELEASE)

AIRBORNE I^{131} ACTIVITY



DEPOSITED I^{131} ACTIVITY