UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

OCT 25 1968

Richard E. Cunningham/Cecil R. Buchanan

RE PROPOSED RADIOISOTOPE PROCESSING FACILITY - UNITED STATES RADIUM CORPORATION

Enclosed are two copies of a preliminary safety analysis of a radioisotope processing facility currently being considered by U. S. Radium Corporation as a possible alternate to the one they have previously discussed with us. Location of the alternate would be on the site of the existing Bloomsburg facility, and would be considered to be a stop-gap facility pending expansion of the business to a level sufficient to support the more extensive facility previously proposed.

Mr. Orville Olson, a recently acquired employee of U. S. Radium discussed the proposed facility and his analysis of the health physics aspects, with particular respect to the question of radioactive effluents. He indicated that they would expect little or no aqueous effluents, and the gaseous effluents would contain only tritium, as U. S. Radium plans to discontinue its activities with other isotopes by the end of the year.

Messrs. Sorenson and Olson were told that the safety evaluation needed to be augmented by a consideration of the possible offsite exposures to people resulting from the expected levels of gaseous activity release, and would have to show that these were within the limits implied in paragraph 20.106(e) of Part 20. This question arises in connection with the Bloomsburg facility because of the close proximity of two private residences to the plant boundary. Messrs. Sorenson and Olson were also informed that they should submit the same sort of information regarding this facility as they would have submitted for the previously proposed New Jersey facility.

J. A. McBride, Director
Division of Materials Licensing

Enclosure:
SAFETY ANALYSIS REPORT (2)

cc: L. D. Low, w/o encl.
L. R. Rogers, w/o encl.

SAFETY ANALYSIS REPORT
for
PROPOSED RADIOISOTOPE PROCESSING FACILITY

UNITED STATES RADIUM CORPORATION

BLOOMSBURG, PENNSYLVANIA

-- O. L. Olson, Health Physicist

# INTRODUCTION

This Safety Analysis Report describes a facility planned for manufacturing tritiated metal foils and tritium activated self-luminous light tubes. The facility is to be located on the United States Radium Corporation property at 4150 Old Berwick Road, Bloomsburg, Pennsylvania.

The facility will be designed to meet performance specifications which will assure safe operation for employees and occupants in surrounding unrestricted areas. Specifically, the performance specifications are selected to assure operation within all applicable limits established for radioisotope licensing by state and federal agencies.

## PURPOSE OF FACILITY

### Primary purpose

The primary purpose of this facility is to provide improved housing for new equipment to be used for manufacturing tritiated metal foils and tritium activated light tubes.

### Secondary purpose

It is planned to move all radioisotope processing existing at the Bloomsburg location into this facility in order to provide improved housing for all radioisotope operations.

## GENERAL DESCRIPTION OF FACILITY

Radioisotope processing will be housed in a new, one-story building set on a concrete slab. The radioisotope processing area will be approximately 5000 square feet. If a non-radioisotope area, e.g. an office area, is attached to the building, the ventilation systems for the radioactive and non-radioactive areas will be separate and isolated by pressure differentials across airlocks.

The radioisotope area ventilation system will exhaust by way of a filter bank and exhaust stack. The stack will be located in the center of a restricted area large enough to provide for a tolerable annual release of 1000 curies of tritium. This compares to a total predicted release of 425 curies from all tritium sources in 1968.

Liquid effluent from potentially contaminated sources will be processed through the existing liquid effluent disposal facility. This facility provides the capability for removal of radioisotopes by evaporation and ion exchange. Quantitative dilution is also provided for disposal of tritium.

Solid radioactive waste will be disposed of by contract with a licensed firm for burial in an AEC approved burial ground.

## DESCRIPTION OF BUILDING

Building ventilation

If an office area, or other non-radioactive area, should be added to the building, the ventilation system would be separate and isolated from the radioisotope processing area by air locks. A pressure differential of 0.05 inch water gauge will be maintained to assure positive air flow into the radioisotope area.

A pressure differential of 0.1 inches water gauge will be maintained between the radioisotope area and outdoors. Outside entrances will be protected by air locks if they are to be used routinely. Other openings to the outside will be opened only after approval by the facility manager who will assure that operations in process will not create a radiation hazard due to loss of building air balance.

Within the radioisotope area, the ventilation system will be designed to provide six (6) air changes per hour. The air balance within the area will be designed to maintain positive flow from hallways into individual rooms and out through the exhaust system.

Ventilation air from the radioisotopes area will not be recirculated.

Intake air will be passed through dust-stop type filters to reduce the ventilation air dust load.

A system of dampers will be provided in the ventilation ducts such that a desirable building air balance can be maintained by routine survey and adjustment.

Building ventilation exhaust

The building exhaust system will be designed on the principle of stopping effluents at the source. Primary filtration at each work station will be designed to capture filterable effluent.

Dust-stop type filters will be located in the exhaust plenum just ahead of the main blower(s) which will power the building exhaust system.

Building surface contamination control

Control of surface contamination will be accomplished by providing work station equipment and work procedures designed to minimize the generation of surface contamination.

Protective clothing will be utilized to restrict the movement of radioisotope surface contamination.

Entrance to and exit from the radioisotope area will be through change rooms where protective clothing change procedures will be followed to prevent movement of surface contamination out of the area.

Rooms in the radioisotope area that have a high probability of surface contamination will be painted with epoxy type paint which facilitates decontamination.

Control of contaminated liquid effluent

Contaminated aqueous liquid lines will drain to the existing liquid waste disposal processing facility for appropriate monitoring and processing.

Contaminated organic liquids will be absorbed on an absorbent, then packaged and disposed of as solid waste.

All potentially contaminated liquids will be analyzed for radioisotopes prior to release to the environment to assure that all liquid effluent releases conform to applicable regulations.

Control of direct radiation hazards

Brehmsstrahlung radiation frpm tritiated foils will be the only significant source of direct radiation in this facility. Appropriate handling procedures and, where required, radiation shielding will be provided.

The radiation hazard from brehmsstrahlung is not a major problem. In AERE-M1169, it is shown that brehmsstrahlung from a tritiated titanium foil is 1.8 mrad/hr/Ci at 10 cm. These targets have a nominal 4 curies of tritium with a range of 2 to 10 curies for special orders.

EVALUATION OF RADIATION HAZARD TO ENVIRONMENT

Airborne radioactive effluents - routine

In this evaluation, the annual tolerable tritium release from a stack located at the center of two different sized circular restricted areas was calculated by three well-known atmospheric dispersion equations. Figure 1 shows how these restricted areas might be located on the Bloomsburg property. Table I gives the results of the atmospheric dispersion calculations.

TABLE I

Calculated Tolerable Annual Release of Tritium

| Restricted area radius ft. | Author of equation used | Tolerable Ci/year |
|---|---|---|
| 260 | Turner | 1094 |
| 260 | Sutton | 3137 |
| 260 | Bosanquet & Pearson | 891 |
| 320 | Turner | 1585 |
| 320 | Sutton | 4394 |
| 320 | Bosanquet & Pearson | 1310 |

Values obtained by the Turner and Bosanquet-Pearson methods are considered to be more accurate than the values obtained from Sutton's equation. An explanation of the differences involves an analysis of atmospheric dispersion parameters used in each equation. Such an analysis is beyond the scope of this report. an analysis must be made sometime -

## MAXIMUM CREDIBLE ACCIDENT

### Definition of maximum credible accident

For this report Maximum Credible Accident is defined as the event which could release the greatest amount of tritium to unrestricted areas in 24 consecutive hours. For purposes of this report "Acts of God" are not included in the evaluations to determine the maximum credible accident. Fire originating within the building is included in the determination of maximum credible accident.

### Description of maximum credible accident

The maximum credible accident in this facility would be the release of the total working volume of tritium from the tritium handling equipment. Such an accident could release 4000 curies of tritium which would be carried by the ventilation exhaust system out through the exhaust stack.

The foil tritiating equipment and the luminous tube filling equipment each have a tritium working volume of 4000 curies. Under separate headings, a discussion of accident probability for each unit is presented.

The radiation hazard which could be generated is indicated by the calculated values in Table II.

TABLE II

Maximum Tritium Concentrations at Points of Interest Following a Release of 4000 Ci/24 Hours

| Atomospheric stability | Wind speed MPH | Point of Interest | µCi/cc 24-hr average | Feet downwind from stack |
|---|---|---|---|---|
| very stable | 2 | plume centerline | $1 \times 10^{-3}$ | 260 |
| very stable | 2 | plume centerline | $7.8 \times 10^{-4}$ | 320 |
| very stable | 2 | maximum ground level | $3.2 \times 10^{-6}$ | 8690 |
| average | 2 | maximum ground level | $1.7 \times 10^{-4}$ | 476 |

The values in Table II are nominal values. It is extremely unlikely that the exact atmospheric conditions chosen here would occur simultaneously with the other factors required to produce the maximum credible accident.

As can be seen from the table, average weather conditions with a low wind speed create the highest ground level radiation hazard. In the Bloomsburg area, such conditions are extremely unlikely. The average wind speed for all months is well above 2 miles per hour. A review of Local Climatological Data published by Environment Science Services Administration for 1967 at the Williamsport, Pennsylvania airport shows a mean annual wind speed of 8.1 miles an hour. July, August and September had the low mean hourly speed by the month. It was 6.8 miles per hour in each month. Meteorological conditions at Bloomsburg are very similar to those at Williamsport because the general topography is similar and the river valleys run in the same general direction.

The prevailing wind direction at Williamsport in 1967 was west for all months except February and September when it became west northwest.

Data on Routine Releases of $^3H$

| Stack No | Operation Served | Ci/yr, 1968 | Ci/yr Projected |
|---|---|---|---|
| 2 | Resin Mfg | 85 | 0* |
| 9 | Gas Filling System | 200 | 360** |
| 10 | Tritium Foil Mfg | 20 | 20 |
| 11 | Dark Rooms | 12 | 6 |
| 14 | applications area (dial + hand painting, etc) | 82 | 40 |
| 15 | Watch dials (silk screening operation on sheets) | 24 | 0* |
| | | 423 | 426 |

* Plan to discontinue this operation

** new, more efficient equipment, increase due to increased scale of operation

Plan to use single, 54 foot stack.

## OPERATION OF TUBE FILLING EQUIPMENT

### Description of equipment

This system consists basically of an ultra high vacuum system to remove the air from the tubes to be filled. A tritium supply section with a uranium tritide container as the source of tritium for filling the tubes and a high sensitivity bellows type pressure gauge. A "pull-back" section which utilizes a uranium container to remove the tritium from the system and from the unused portion of the tubes that have been filled. There are cross-over lines connecting the pull-back section and the fill section. The tritium is reclaimed by heating the uranium pull-back container and absorbing the released tritium on the uranium tritide supply container.

The system is a semi-automatic Sorption and Ion pumped system that consists of three modules designed to operate under a single exhaust hood. A central tritium supply section and pull-back section are used for all three modules. Each module fills and seals a group of forty tubes on a manifold per cycle. Each module is expected to cycle three times per shift for a total of three hundred and sixty filled tubes.

The sorption pump absorbs and holds all pumped gases with the exception of helium while it is at liquid nitrogen temperature. The gases, as they are removed during the reactivation of the sorption pump,

are scrubbed to remove any tritium present, before release to the exhaust hood. The ion pump collects and permanently holds all pumped gases.

A single operator's attendance is required at each module during loading, start of the automatic pumping sequence, the duration of the fill cycle, the start of the sealing operations, and the start of the pull-back and pump sequence. The system is designed so that in the event of a leak during the tritium fill cycle or the sealing operation on any module, all valves are automatically closed except the valve to the pull-back sections which opens and retracts the tritium into the uranium container. This emergency pull-back procedure may be manually activated by the operator at any time that it is necessary. The system is designed so that all valves may be manually operated or by-passed when necessary.

The sealing of the glass tubes is accomplished by focused infrared radiation. The tubes are annealed by the unfocused radiation that is emitted by the lamps.

A tritium air monitor installed in the hood exhaust system alerts the operator to any release of tritium, also at a pre-set level initiates the emergency pull-back sequence as previously described. The system is designed to be fail safe. In event of a power failure or a compressed air failure, all the automatic valves will close. Manual bypass valves may then be opened to return the tritium to the uranium container, if necessary.

This system has been designed to encompass high quality materials of construction, most modern techniques of assembly, and safe and easy operation and maintenance.

DISCUSSION OF POTENTIAL RADIATION HAZARD
FROM OPERATION OF LUMINOUS TUBE FILLING EQUIPMENT

Accidental release of tritium from new fill system

There are four possible points of accidental release of tritium from the new fill system. These are listed in the order of probability of occurrence, the first being the most frequent.

1) A leak at the glass to metal seal. Our experience in 3 years operating the existing system shows that this would never exceed 10 mCi per hour and that the duration at this level would never be longer than 5 minutes.

2) Complete rupture of a tube while on the manifold. There will be an estimated 400 Ci of tritium in this section at less than atmospheric pressure. The operating schedule of this system is such that the operator must be present while the tritium is in this section. It cannot be visualized how it would be possible to lose in excess of 50 Ci with the emergency procedure that will be set up.

3) Leaks in the gas handling section of the system. The release rate would never exceed 5 mCi per hour with a maximum duration of 10 minutes.

4) Operator error. This is very unlikely to occur, due to the system fail safe automation. If an operator or the automation of the system failed, the tritium would either be contained in the ion pump or trapped in the sorption pump. A special emergency procedure will be set up to strip this absorbed tritium from the sorption pump, if this should occur.

## DESCRIPTION OF FOIL TRITIATING PROCESS

### Description of equipment

Existing equipment is described here because design for new equipment has not been established yet.

Metal foils are tritiated in a quartz pot with an absolute pressure not greater than two-thirds atmospheric pressure.

Tritium gas is stored on uranium in steel pots. It is moved by a diffusion pump/mechanical pump system which is used to evacuate the system.

Tritium in exhaust from the system is passed through an oil demister, a molecular sieve to remove tritiated water, a copper oxide furnace to oxidize gaseous tritium, and through a second molecular sieve to assure capture of all tritium.

The complete system is enclosed in a glovebox which is exhausted through a tritium removal train to the exhaust stack.

### Discussion of potential radiation hazard from operation of foil tritiating equipment

The most probable accidental release of tritium from this equipment would be the loss of 100 to 150 curies during an initial step in the process when a small amount of tritium is moved from the storage pots to the quartz impregnation pot to test the system. The resulting concentration in the environment would be .04 times the values in

Table II if all scrubbing of effluent tritium at the glovebox failed. In a new design, the capacity of the glovebox effluent scrubbing system would be redesigned to a capacity to capture tritium leaks at the glovebox outlet port.

As was explained under Description of Equipment, tritium which is flushed from the equipment as an inevitable consequence of processing is captured by a molecular sieve-copper oxide system.

New equipment would be designed to provide "tritium capture" capacity to reduce the release hazard as much as reasonable cost will allow.

DESCRIPTION OF EQUIPMENT FOR SPECIAL LUMINOUS TUBES

Description of equipment

The details of this equipment have not been developed. It will be a small gas filling unit designed for development work and short production runs of special items.

Performance specifications will require that the maximum credible accidental release not cause unrestricted area concentrations in excess of 500 X unrestricted area limit and that the most probable operating accident release not cause concentrations in excess of unrestricted area limits.

## CONTINUOUS EFFLUENT STACK MONITORING

### Description of equipment

The effluent stack will be monitored by a train of monitors that includes a particulate filter, an ionization chamber, and a water impinger. The particulate filter will be counted daily in a proportional counter; the water impinger sample will be counted daily in a liquid scintillation counter; the ionization chamber output will be recorded continuously on a chart recorder.

The ionization chamber will be a 14.8 liter Applied Health Physics unit feeding the signal to a Cary 401 vibrating reed electrometer which activates a recording pen on a Honeywell chart recorder.

### Discussion of effluent stack monitoring

The effluent stack will be monitored continuously - 24 hours a day. As currently planned, the monitoring equipment will have a nominal sensitivity of $1 \times 10^{-6}$ µCi/cc for tritium in air. It will be sampling a stack flow at a location in the stack to produce a representative sample of stack effluent.

An instantaneous alarm system adjustable to predetermined levels will be attached to the monitoring system.

Experience has shown that the ratio of tritium activity as particulate, water soluble, and gas is fairly constant. It is possible, therefore, to integrate tritium effluent recorded by the ionization chamber and calculate the total tritium effluent from all three types.

# ROOM AIR MONITORING

## Discussion of room air monitoring

During the first few months of operation in this facility, it is planned to do continuous air monitoring for tritium in each room of the radioisotope area by utilizing several Johnston Triton units to provide a record of tritium levels and to provide alarm capability.

Water impinger samplers will also be utilized extensively for several months to provide data which can be compared with the Triton sampler data.

From the data collected during the first several months of operation, a determination will be made as to the need and design of a permanent air monitoring system which would operate from a "house vacuum" system.

# FIRE CONTROL IN RADIOISOTOPE AREA

## Description of equipment

An automatic sprinkler system and construction of the building will, of course, be designed to meet applicable local fire control codes. In this facility, however, the effect of automatic sprinkler spray must be carefully analyzed. First, it may not be desirable to sprinkle equipment such as the tube filling system because unplanned closed circuits might set up an undesirable valving sequence. Some automatic shutdown of the tritium processing equipment will have to be coupled with the sprinkler system.

Another factor to be evaluated is the effect of automatic sprinkling on stack effluent temperature. If the stack exit temperature is lowered, the dispersion of effluent, dilution factor, is reduced significantly.

Selection of materials and procedural controls will be utilized to prevent the accumulation of flammable materials in the radioisotope area.

# PERSONNEL MONITORING PROGRAM

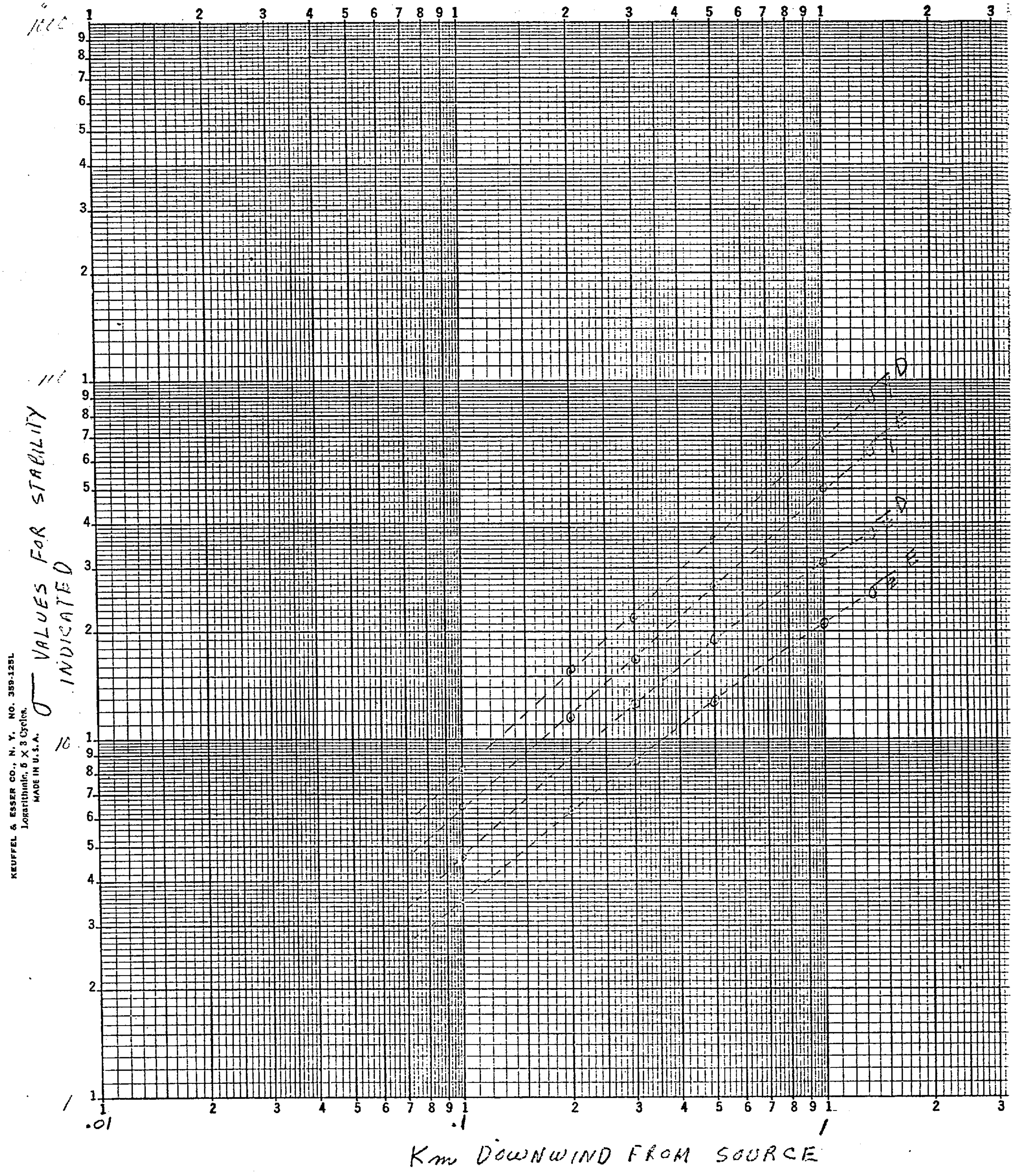
## Airborne contamination exposure monitoring

During initial operating periods, breathing zone samples will be obtained for the personnel involved. Once the operation of a piece of equipment is stabilized, it is planned to use stationary samplers located in each room. Currently, it is planned to draw air from each work station in a room to a central room sampler to obtain a daily integrated sample for the room. This program would be coordinated with the program discussed under Room Air Monitoring.

The sampling for personnel monitoring would initially be performed by use of Johnston Triton units and personal water impinger units. If the initial data justify the need, a system of Kanne chambers or permanently installed Johnston Tritons will be provided as part of a permanent system.

## Bioassay program

Initially, daily urine samples from each work in the radioisotope area will be analyzed for tritium. Data from the daily urine sample program will be analyzed to define a permanent routine tritium urinalysis program. In any case, all radioisotope area workers will be requested to submit a minimum of one urine sample each work week for tritium analysis.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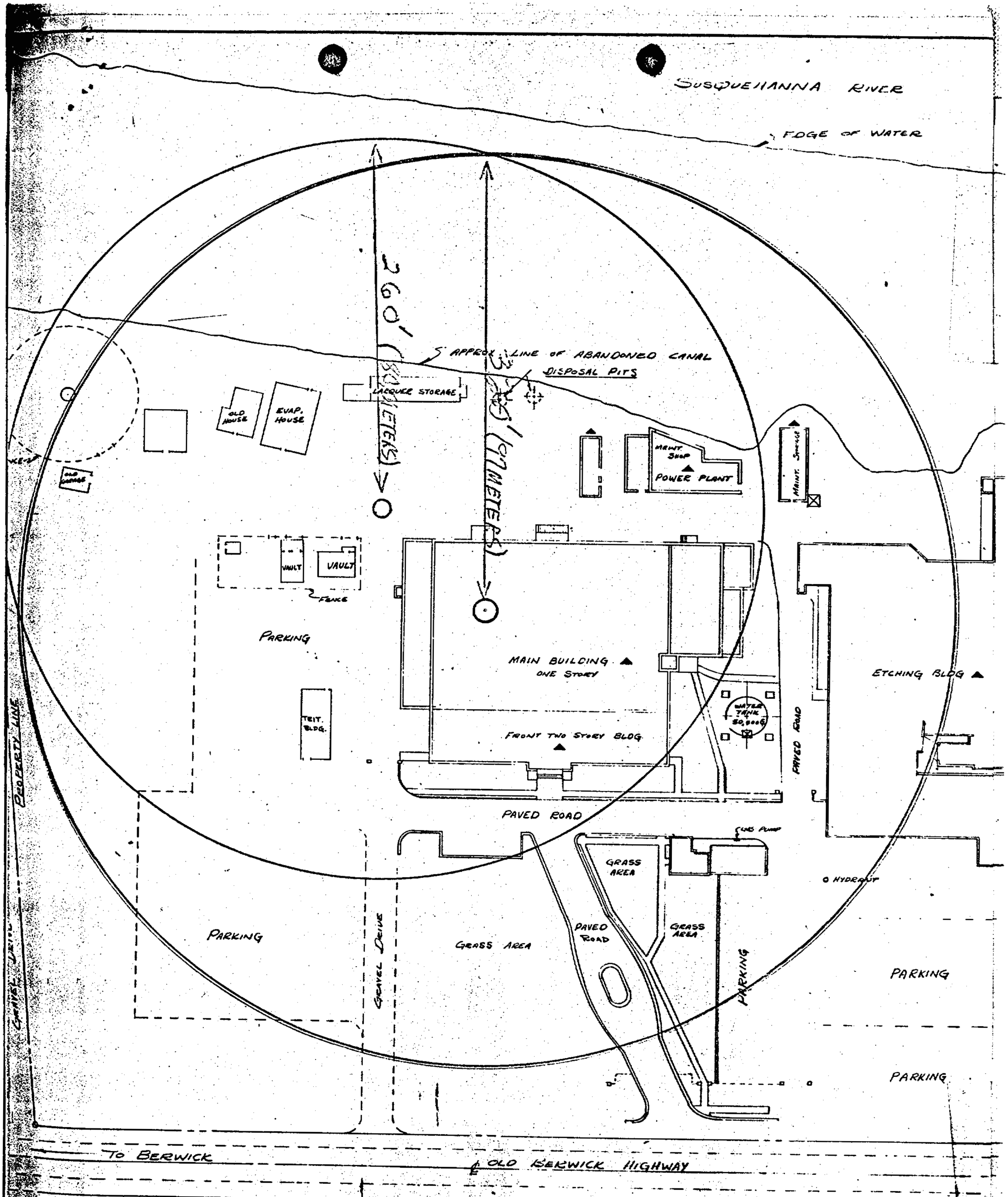
SUSQUEHANNA RIVER
EDGE OF WATER
260' (80 METERS)
330' (97 METERS)
APPROX. LINE OF ABANDONED CANAL
DISPOSAL PITS
LACQUER STORAGE
OLD HOUSE
EVAP. HOUSE
MAINT. SHOP
POWER PLANT
MAINT. SERVICE
VAULT
VAULT
FENCE
PARKING
MAIN BUILDING
ONE STORY
FRONT TWO STORY BLDG.
TEIT. BLDG.
WATER TANK 50,000 G
PAVED ROAD
ETCHING BLDG
PAVED ROAD
GAS PUMP
GRASS AREA
HYDRANT
PARKING
GRAVEL DRIVE
GRASS AREA
PAVED ROAD
GRASS AREA
PARKING
PARKING
PARKING
PROPERTY LINE
TO BERWICK
OLD BERWICK HIGHWAY

FIG. 1

LATITUDE 41° 15' N
LONGITUDE 76° 55' W
ELEVATION (ground) 524 Feet

# METEOROLOGICAL DATA FOR THE CURRENT YEAR

WILLIAMSPORT, PENNSYLVANIA
WILLIAMSPORT AIRPORT
1967

| Month | Temperature: Averages: Daily maximum | Daily minimum | Monthly | Extremes: Highest | Date | Lowest | Date | Degree days | Precipitation: Total | Greatest in 24 hrs. | Date | Snow, Sleet: Total | Greatest in 24 hrs. | Date | Relative humidity: 1 AM | 7 AM | 1 PM | 7 PM (Standard time used: EASTERN) | Wind &: Resultant: Direction | Speed | Average speed | Fastest mile: Speed | Direction | Date | Percent of possible sunshine | Average sky cover sunrise to sunset | Number of days: Sunrise to sunset: Clear | Partly cloudy | Cloudy | Precipitation .01 inch or more | Snow, Sleet 1.0 inch or more | Thunderstorms | Heavy fog | Temperatures: Maximum: 90° and above | 32° and below | Minimum: 32° and below | 0° and below |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JAN | 38.6 | 24.1 | 31.4 | 69 | 25 | 6 | 19 | 1035 | 1.35 | 0.83 | 27-28 | 3.0 | 1.3 | 31 | 88 | 85 | 71 | 77 | 28 | 2.2 | 8.0 | 29 | 11 | 27 | | 7.7 | 2 | 8 | 21 | 10 | 1 | 1 | 2 | 0 | 9 | 26 | 0 |
| FEB | 32.1 | 14.9 | 23.5 | 57 | 15 | - 9 | 8 | 1157 | 1.49 | 0.36 | .2 | 17.6 | 4.8 | 17-18 | 80 | 80 | 63 | 63 | 27 | 3.1 | 10.4 | 40 | 26 | 16 | | 7.2 | 3 | 10 | 15 | 13 | 6 | 0 | 0 | 0 | 14 | 28 | 3 |
| MAR | 43.4 | 25.1 | 34.3 | 66 | 31 | - 1 | 19 | 946 | 5.36 | 1.48 | 6-7 | 29.5 | 13.9 | 6-7 | 82 | 83 | 63 | 70 | 01 | 1.2 | 7.7 | 25 | 26 | 3 | | 7.0 | 6 | 8 | 17 | 15 | 8 | 1 | 3 | 0 | 4 | 24 | 1 |
| APR | 62.0 | 38.7 | 50.4 | 83 | 15 | 28 | 4 | 437 | 2.88 | 0.82 | 26-27 | 2.7 | 2.2 | 24 | 66 | 74 | 45 | 49 | 31 | 3.8 | 10.1 | 29 | 25 | 22 | | 6.2 | 8 | 9 | 13 | 14 | 1 | 2 | 0 | 0 | 0 | 6 | 0 |
| MAY | 64.5 | 41.1 | 52.8 | 81 | 27 | 31 | 13 | 371 | 5.50 | 1.04 | 29 | T | T | 6 | 84 | 81 | 50 | 56 | 31 | 2.5 | 8.9 | 32 | 27 | 19 | | 6.9 | 5 | 11 | 15 | 12 | 0 | 4 | 2 | 0 | 0 | 2 | 0 |
| JUN | 83.5 | 58.9 | 71.2 | 92 | 13+ | 42 | 1 | 5 | 3.24 | 1.60 | 13-14 | 0.0 | 0.0 | | 91 | 88 | 55 | 63 | 17 | 1.3 | 6.6 | 36 | 30 | 15 | | 5.4 | 10 | 12 | 8 | 11 | 0 | 8 | 2 | 6 | 0 | 0 | 0 |
| JUL | 81.2 | 61.5 | 71.4 | 88 | 1 | 51 | 6 | 5 | 6.03 | 1.66 | 28 | 0.0 | 0.0 | | 97 | 96 | 65 | 75 | 25 | 2.1 | 6.3 | 28 | 24 | 4 | | 7.3 | 1 | 14 | 16 | 13 | 0 | 9 | 7 | 0 | 0 | 0 | 0 |
| AUG | 78.3 | 60.4 | 69.4 | 86 | 4 | 49 | 31 | 12 | 4.97 | 0.97 | 7-8 | 0.0 | 0.0 | | 98 | 98 | 71 | 80 | 24 | 1.1 | 5.9 | 21 | 14 | 3+ | | 7.6 | 2 | 13 | 16 | 14 | 0 | 5 | 8 | 0 | 0 | 0 | 0 |
| SEP | 75.3 | 51.3 | 63.3 | 84 | 18 | 41 | 25 | 109 | 2.20 | 0.90 | 28-29 | 0.0 | 0.0 | | 91 | 94 | 57 | 75 | 28 | 2.8 | 7.7 | 23 | 11 | 28 | | 5.6 | 9 | 10 | 11 | 7 | 0 | 2 | 7 | 0 | 0 | 0 | 0 |
| OCT | 62.4 | 41.2 | 51.8 | 84 | 4 | 25 | 30 | 406 | 4.50 | 2.08 | 25 | 0.0 | 0.0 | | 88 | 90 | 63 | 78 | 23 | 1.2 | 7.2 | 25 | 25 | 18 | | 7.0 | 7 | 6 | 18 | 8 | 0 | 2 | 7 | 0 | 0 | 8 | 0 |
| NOV | 46.3 | 29.4 | 37.9 | 66 | 1 | 14 | 16 | 807 | 3.63 | 1.25 | 2 | 9.8 | 4.3 | 30 | 81 | 80 | 62 | 73 | 27 | 4.0 | 8.9 | 33 | 23 | 12 | | 7.7 | 1 | 12 | 17 | 12 | 3 | 1 | 2 | 0 | 1 | 18 | 0 |
| DEC | 41.1 | 25.8 | 33.5 | 56 | 13 | 2 | 30 | 973 | 2.71 | 0.75 | 3 | 10.4 | 6.7 | 28-29 | 81 | 82 | 64 | 69 | 29 | 2.6 | 8.2 | 23 | 29 | 15 | | 7.8 | 3 | 7 | 21 | 12 | 2 | 2 | 1 | 0 | 7 | 22 | 0 |
| YEAR | 59.1 | 39.4 | 49.3 | 92 | JUN. 13+ | - 9 | FEB. 8 | 6263 | 43.86 | 2.08 | OCT. 25 | 73.0 | 13.9 | MAR. 6-7 | 86 | 86 | 61 | 69 | 28 | 1.9 | 8.0 | 40 | 26 | FEB. 16 | | 7.0 | 57 | 120 | 188 | 141 | 21 | 37 | 41 | 6 | 35 | 134 | 4 |

# NORMALS, MEANS, AND EXTREMES

| Month | Temperature: Normal: Daily maximum | Daily minimum | Monthly | Extremes: Record highest | Year | Record lowest | Year | Normal degree days | Precipitation: Normal total | Maximum monthly | Year | Minimum monthly | Year | Maximum in 24 hrs. | Year | Snow, Sleet: Mean total | Maximum monthly | Year | Maximum in 24 hrs. | Year | Relative humidity: 1 AM | 7 AM | 1 PM | 7 PM (Standard time used: EASTERN) | Wind &: Mean hourly speed | Prevailing direction | Fastest mile: Speed | Direction | Year | Pct. of possible sunshine | Mean sky cover sunrise to sunset | Mean number of days: Sunrise to sunset: Clear | Partly cloudy | Cloudy | Precipitation .01 inch or more | Snow, Sleet 1.0 inch or more | Thunderstorms | Heavy fog | Temperatures: Max.: 90° and above | 32° and below | Min.: 32° and below | 0° and below |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (a) | (b) | (b) | (b) | 23 | | 23 | | (b) | (b) | 23 | | 23 | | 23 | | 23 | 23 | | 23 | | 17 | 23 | 23 | 23 | 7 | 3 | 14 | 14 | | | 23 | 23 | 23 | 23 | 23 | 23 | 7 | 7 | 23 | 23 | 23 | 23 |
| J | 36.1 | 21.4 | 28.8 | 69 | 1967 | -14 | 1948 | 1122 | 2.67 | 4.95 | 1964+ | 0.99 | 1955 | 1.49 | 1964 | 10.2 | 33.5 | 1964 | 23.1 | 1964 | 75 | 76 | 62 | 69 | 9.2 | W | 66 | 27 | 1951+ | | 7.3 | 5 | 7 | 19 | 13 | 3 | 1 | 1 | 0 | 11 | 28 | 2 |
| F | 37.6 | 20.8 | 29.2 | 71 | 1954 | -11 | 1948 | 1002 | 2.51 | 4.81 | 1960 | 0.67 | 1947 | 2.05 | 1966 | 10.9 | 25.2 | 1964 | 16.5 | 1964 | 74 | 76 | 59 | 66 | 9.8 | WNW | 60 | 14 | 1951 | | 7.0 | 5 | 7 | 16 | 12 | 3 | * | 2 | 0 | 7 | 26 | 1 |
| M | 46.6 | 28.1 | 37.4 | 83 | 1945 | - 1 | 1967 | 856 | 3.73 | 5.52 | 1950 | 1.29 | 1949 | 2.52 | 1964 | 9.4 | 29.5 | 1967 | 13.9 | 1967 | 75 | 77 | 54 | 62 | 9.2 | W | 58 | 11 | 1954 | | 6.8 | 6 | 8 | 17 | 14 | 2 | 1 | 2 | 0 | 2 | 22 | * |
| A | 60.2 | 38.6 | 49.4 | 91 | 1960 | 18 | 1965+ | 468 | 3.55 | 6.30 | 1957 | 0.99 | 1946 | 1.90 | 1952 | 1.2 | 7.9 | 1961 | 5.0 | 1961 | 74 | 76 | 49 | 57 | 9.4 | W | 62 | 18 | 1950 | | 7.0 | 5 | 8 | 17 | 14 | * | 2 | 1 | * | 0 | 8 | 0 |
| M | 72.0 | 48.7 | 60.4 | 95 | 1962+ | 28 | 1966 | 177 | 4.08 | 9.45 | 1946 | 0.80 | 1964 | 4.15 | 1946 | T | T | 1967+ | T | 1967+ | 81 | 78 | 50 | 57 | 8.2 | W | 55 | 18 | 1953 | | 6.8 | 5 | 11 | 15 | 13 | 0 | 4 | 2 | 1 | 0 | 1 | 0 |
| J | 80.5 | 57.9 | 69.2 | 102 | 1952 | 36 | 1945 | 24 | 3.23 | 5.74 | 1957 | 0.66 | 1966 | 2.26 | 1961 | 0.0 | 0.0 | | 0.0 | | 87 | 83 | 52 | 60 | 7.0 | W | 62 | 29 | 1951 | | 6.1 | 6 | 13 | 11 | 11 | 0 | 6 | 2 | 4 | 0 | 0 | 0 |
| J | 85.3 | 61.8 | 73.6 | 100 | 1966+ | 43 | 1965+ | 0 | 4.18 | 8.30 | 1958 | 0.99 | 1955 | 2.53 | 1958 | 0.0 | 0.0 | | 0.0 | | 89 | 86 | 52 | 63 | 6.8 | W | 78 | 20 | 1951 | | 6.1 | 6 | 14 | 11 | 12 | 0 | 9 | 3 | 7 | 0 | 0 | 0 |
| A | 83.1 | 60.0 | 71.6 | 100 | 1955 | 38 | 1965 | 9 | 3.62 | 7.67 | 1955 | 0.96 | 1951 | 3.46 | 1950 | 0.0 | 0.0 | | 0.0 | | 90 | 90 | 56 | 70 | 6.8 | W | 60 | 29 | 1949 | | 6.3 | 6 | 14 | 11 | 11 | 0 | 6 | 5 | 3 | 0 | 0 | 0 |
| S | 75.4 | 52.8 | 64.1 | 102 | 1953 | 28 | 1947 | 111 | 3.27 | 6.36 | 1945 | 0.50 | 1964 | 2.80 | 1946 | 0.0 | 0.0 | | 0.0 | | 90 | 91 | 57 | 74 | 6.8 | WNW | 59 | 16 | 1951 | | 6.3 | 7 | 10 | 13 | 9 | 0 | 3 | 7 | 1 | 0 | * | 0 |
| O | 64.0 | 42.1 | 53.1 | 91 | 1951 | 20 | 1952 | 375 | 3.32 | 7.78 | 1955 | 0.19 | 1963 | 4.38 | 1955 | T | 0.3 | 1962 | 0.3 | 1962 | 86 | 89 | 55 | 72 | 7.0 | W | 75 | 11 | 1954 | | 6.0 | 9 | 9 | 13 | 9 | 0 | 1 | 6 | * | 0 | 5 | 0 |
| N | 49.5 | 32.7 | 41.1 | 83 | 1950 | 12 | 1955+ | 717 | 3.45 | 6.49 | 1948 | 0.89 | 1946 | 3.46 | 1956 | 3.0 | 13.7 | 1953 | 12.1 | 1953 | 81 | 82 | 60 | 71 | 8.2 | W | 77 | 09 | 1950 | | 7.2 | 5 | 7 | 18 | 12 | 1 | 1 | 3 | 0 | 1 | 16 | 0 |
| D | 37.9 | 22.9 | 30.4 | 65 | 1966 | -15 | 1950 | 1073 | 3.04 | 5.08 | 1948 | 0.84 | 1955 | 2.46 | 1952 | 9.2 | 23.1 | 1945 | 13.7 | 1945 | 78 | 79 | 63 | 72 | 8.6 | W | 58 | 16 | 1953 | | 7.4 | 4 | 8 | 19 | 12 | 3 | * | 2 | 0 | 9 | 27 | 1 |
| YR | 60.7 | 40.7 | 50.7 | 102 | SEP. 1953+ | -15 | DEC. 1950 | 5934 | 40.65 | 9.45 | MAY 1946 | 0.19 | OCT. 1963 | 4.38 | OCT. 1955 | 43.9 | 33.5 | JAN. 1964 | 23.1 | JAN. 1964 | 82 | 82 | 56 | 66 | 8.1 | W | 78 | 20 | JUL. 1951 | | 6.7 | 69 | 116 | 180 | 142 | 12 | 34 | 37 | 16 | 30 | 132 | 4 |

(a) Length of record, years.
(b) Climatological standard normals (1931-1960).
* Less than one half.
\+ Also on earlier dates, months or years.
T Trace, an amount too small to measure.
Below-zero temperatures are preceded by a minus sign.
The prevailing direction for wind in the Normals, Means, and Extremes table is from records through 1963.

Unless otherwise indicated, dimensional units used in this bulletin are: temperature in degrees F.; precipitation, including snowfall, in inches; wind movement in miles per hour; and relative humidity in percent. Degree day totals are the sums of the negative departures of average daily temperatures from 65° F. Sleet was included in snowfall totals beginning with July 1948. Heavy fog reduces visibility to 1/4 mile or less.

Sky cover is expressed in a range of 0 for no clouds or obscuring phenomena to 10 for complete sky cover. The number of clear days is based on average cloudiness 0-3; partly cloudy days 4-7; and cloudy days 8-10 tenths.

& Figures instead of letters in a direction column indicate direction in tens of degrees from true North; i.e., 09 - East, 18 - South, 27 - West, 36 - North, and 00 - Calm. Resultant wind is the vector sum of wind directions and speeds divided by the number of observations. If figures appear in the direction column under "Fastest mile" the corresponding speeds are fastest observed 1-minute values.