

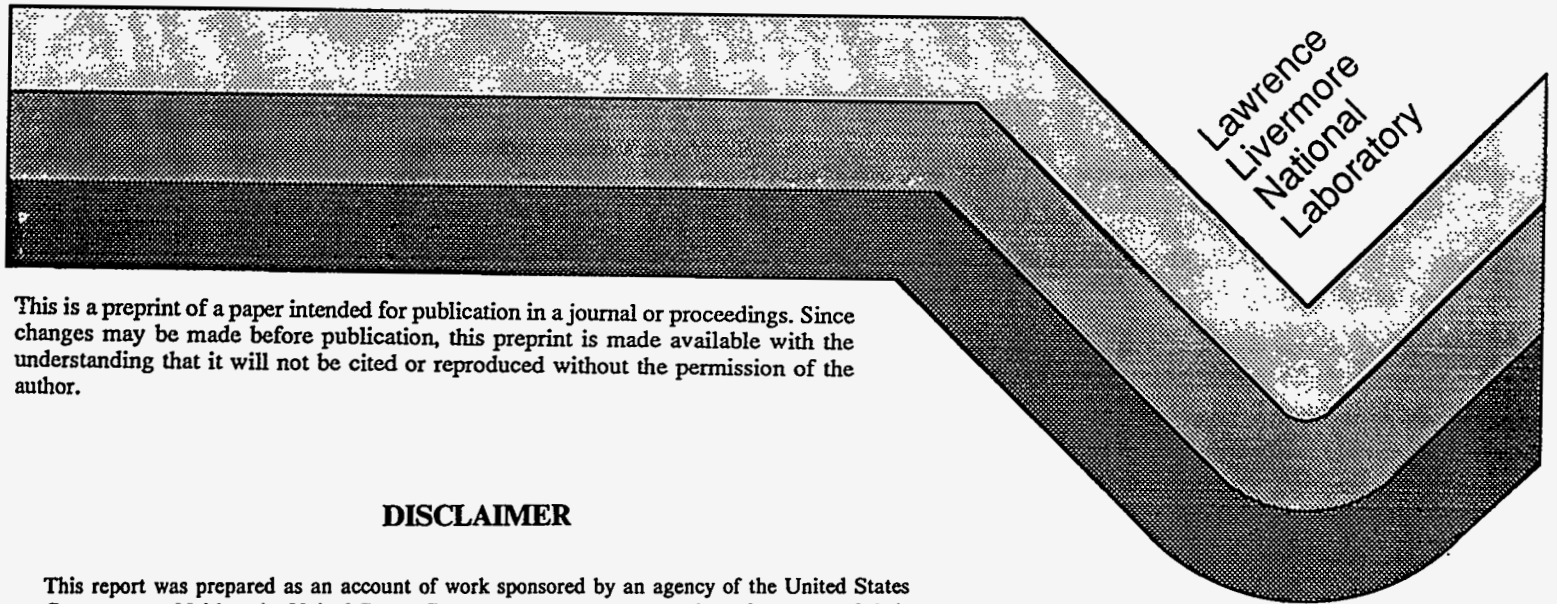
# NTS-SPILL TEST FACILITY WIND TUNNEL EXHAUST PLUME CHARACTERIZATION

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## NTS-SPILL TEST FACILITY WIND TUNNEL EXHAUST PLUME CHARACTERIZATION

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The exhaust plume of the NTS-STF wind tunnel has been characterized to demonstrate its suitability as a target for CALIOPE experiments. Smoke from grenades has been released in multiple quantities and at different positions inside the tunnel. The smoke plume have been recorded on video tape. (A video will be available for viewing.) The wind velocity profile has also been determined with a moveable array of miniature vane anemometers. These measurements will be used to determine the vapor concentration\*pathlength as part of the "ground truth".

The data, both videos and anemometer data were taken during periods of low or no wind (Figure 1). Smoke grenades lasted about two minutes apiece, long enough to reach an equilibrium condition.

A total of 14 smoke releases were performed and recorded on 4 cameras (Figure 2). The smoke grenades were suspended on a framework near the entrance end of the wind tunnel, about 10 feet downstream from where the chemical release nozzles will be placed. A well mixed and distributed smoke plume is then thought to be indicative of a "good" chemical plume. These tests clearly indicated that multiple nozzles must be used and that the nozzles need to be distributed vertically in the wind tunnel. To promote thorough mixing, high speed fans distributed along the wind tunnel will be employed.

The original and edited versions of the wind tunnel smoke videos will be available during test episodes. If users need to study the plume in detail, I can supply a copy. Contact Rod Kerr at 510-423-9542.

The plume velocity was characterized with miniature anemometers (Figure 3). Five anemometers were moved in 6-inch steps across the plume. The component of velocity parallel to the wind tunnel axis was measured at a total of 190 positions. Figure 5 is an XY plot of those positions.

Shown are the data for the 84" position (centered at the user viewing axis) (Figures 4 & 6). The vertical axis is the wind speed, and the maximum is about 3500 ft/min. Of primary interest to users is that the edges all drop off rapidly, so we may be assured of a well defined gas volume. The structure at the top is mostly understood: the crater in the center is caused by the fan mount and pulley housing; the valley from the center to the right is caused by the fan belt housing; and the valley slightly to the left of center is caused by part of the anemometer mounts being too close downwind from the anemometers.

The aim here was to map out the cross-sectional area of the plume, roughly a circle (Figure 5). A pantograph was developed which swept out an arc either above or below the horizontal axis. There is considerable overlap as the detectors are moved to the X-axis extremes. Data were accumulated for 1 minute at a 1 Hz rate at each position prior to moving the pantograph. The data shown are one minute averages of the 60 instantaneous data points for each anemometer.

This is a scale drawing of the plume diagnostic suite and placement (Figures 7 & 8). The diagnostic frames will be supported on four poles located on a 13 ft square. The Infra-Red gas analyzers (Foxboro Miran 1a) will have their sampling tubes attached to moveable tracks, which can be controlled by computer. The FTIR beams will be oriented vertically.

Shown here is a frame from one of the smoke test videos (Figure 9). The scaffolding will not be there at testing time. The test volume will be just to the left of the scaffolding.

## PLUME CHARACTERIZATION

TWO METHODS HAVE BEEN USED

SMOKE GRENADES with VIDEO CAMERAS

MINIATURE VANE ANEMOMETERS

SMOKE GRENADE VIDEO TAPE SUMMARY IS SHOWING CONTINUOUSLY -- FEEL FREE TO VIEW AND ASK QUESTIONS

VANE ANEMOMETER DATA IS ONLY PARTIALLY ANALYZED AND THAT ONLY PRELIMINARY.

Figure 1.

## SMOKE TEST VIDEOS

THERE ARE 6 TESTS DOCUMENTED HERE: NUMBERS 1,2,3,4,10,&11  
EACH TEST HAS MORE THAN ONE CAMERA VIEW

TEST 1: ONE SMOKE GRENADE LOCATED 5 FEET ABOVE FLOOR

TEST 2: TWO GRENADES LOCATED 1 FOOT ABOVE FLOOR

TEST 3: FOUR GRENADES: 2 LOCATED 5 FEET ABOVE FLOOR AND  
2 LOCATED 10 FEET ABOVE FLOOR

TEST 4: 1 GRENADE LOCATED 5 FEET ABOVE FLOOR - NOTE THE  
CAMERA VIEW INSIDE JUST AS THE RELEASE BEGINS

TEST 10: 3 GRENADES ON A VERTICAL LINE AT 5, 8, & 11 FEET  
ABOVE FLOOR. MIXING FANS ALONG WALL

TEST 11: SAME 3 GRENADES, MIXING FANS MOVED UNDER  
SMOKE - NOTE THE VIDEOS OF THE PLUME SHADOW

Figure 2.

### WIND VELOCITY

FIVE SOLOMAT MINIATURE ROTATING VANE ANEMOMETERS WERE ARRANGED ON A FRAME AT 12" CENTERS.

(a total of 10 were planned but remaining 5 have not yet arrived)

THE FRAME WAS SUSPENDED ON A PANTOGRAPH DESIGNED TO SWEEP OUT THE ENTIRE AREA OF THE PLUME.

DATA WERE RECORDED AT 190 POSITIONS NORMAL TO THE PLUME AXIS AT EACH OF THREE LONGITUDINAL POSITIONS.

A COMPLETE CHARACTERIZATION WAS PERFORMED AT 36", 84" AND 132" FROM THE END OF THE LAMINARIZER. THESE ARE THE PLANNED POSITIONS OF THE TWO DIAGNOSTIC ARRAYS AND THE TARGET AREA.

Figure 3.

### RESULTS

ANEMOMETER DATA SHOW VERY CLEARLY THAT THE PLUME IS WELL BEHAVED AND HAS SHARP WELL DEFINED EDGES.

THE PLUME IS EXPANDING AT A SLOW RATE IN THE TARGET REGION.

THESE DATA WILL ENABLE US TO DEFINE THE CONCENTRATION\* PATH LENGHT ADEQUATELY FOR THE EXPERIMENTS.

MOST OF THE STRUCTURE IN THE PLUME VELOCITY IS UNDERSTOOD BASED ON THE MOTOR AND BELT SHROUDS

SOME OF THE DATA POINTS ARE ENEXPECTEDLY LOW - THIS IS CURRENTLY SURMISED TO HAVE BEEN CAUSED BY SOME PECULIARITIES OF THE MEASURING APPARATUS, AND CAN PROBABLY BE CORRECTED.

ADDITIONAL DATA NEED TO BE RECORDED FOR EXPECTED CROSS-WINDS AND WITH LOWER FAN SPEEDS.

Figure 4.



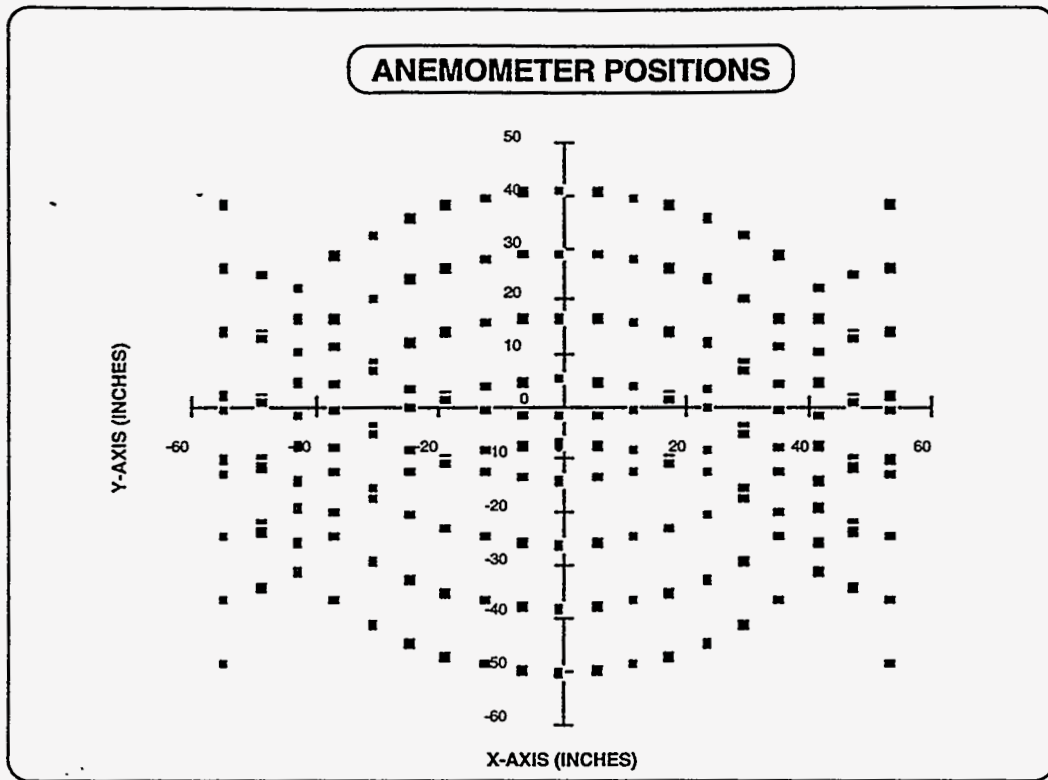


Figure 5.

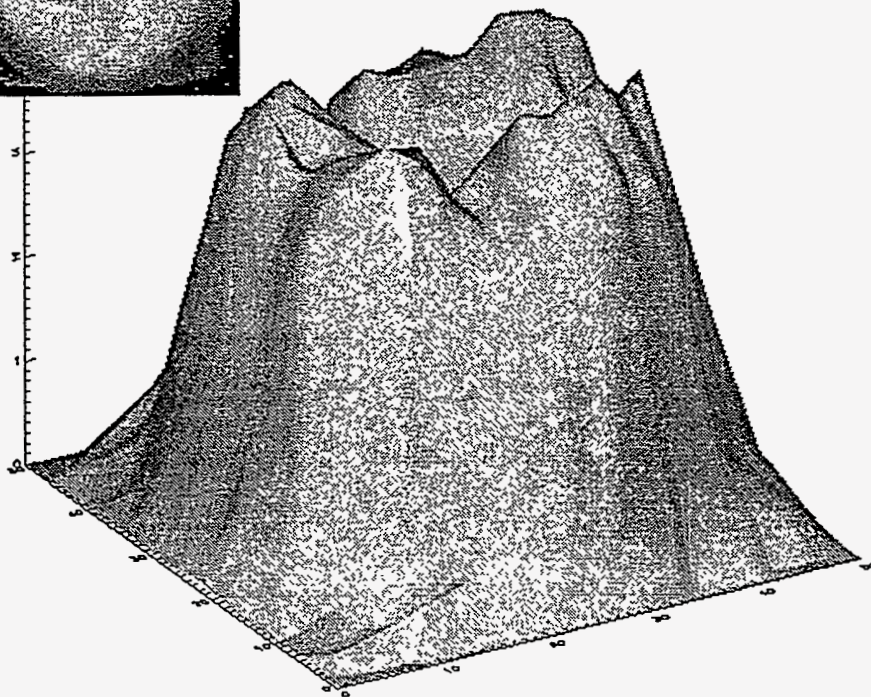
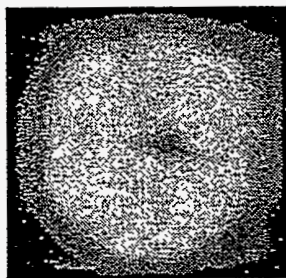


Figure 6.

### WIND TUNNEL PLUME DIAGNOSTICS

- VARIOUS TYPES OF INSTRUMENTATION ARE PLANNED FOR DETERMINING THE "GROUND TRUTH" ABOUT THE PLUME.
- VANE ANEMOMETERS FOR PLUME VELOCITY AND DIRECTION.
- TELL-TALE STRINGS AND VIDEO CAMERAS FOR WIND MONITORING.
- DISPERSIVE INFRA-RED FILTER SPECTROMETERS ON MOVING TRACK IN PLUME TO DETERMINE SPECIES CONCENTRATION.
- FTIR TELESCOPE TO DETERMINE THE CONCENTRATION\*PATH LENGTH PRODUCT AT THE TARGET PLANE.
- PHOTOIONIZATION AND ELECTROCHEMICAL SENSORS FOR PERSONNEL SAFETY.
- GAS CHROMATOGRAPHS FOR APPLICABLE SPECIES.
- QUADRUPOLE MASS SPECTROMETERS WHEN % GET LOW.
- IMAGING IR CAMERA IF AVAILABLE.

Figure 7.

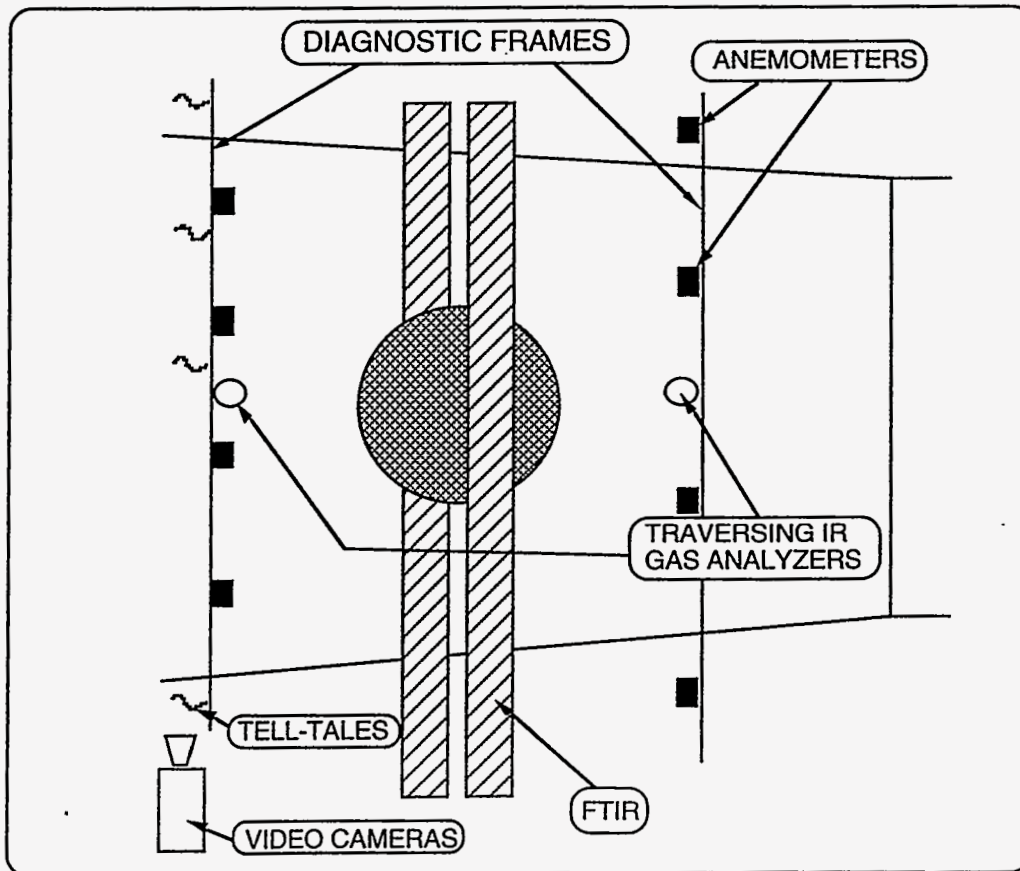


Figure 8.





Figure 9.

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