P7.5 EXTREME METEOROLOGICAL PARAMETERS DURING SPACE SHUTTLE PAD EXPOSURE PERIODS

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1. INTRODUCTION

During the 113 missions of the Space Transportation System (STS), the Space Shuttle fleet has been exposed to the elements on the launch pad for a total of 4195 days. This paper provides a summary of the historical record of the meteorological extremes encountered by the Space Shuttle fleet during the pad exposure period. Parameters included are temperature, dew point, relative humidity, wind speed, sea level pressure and precipitation. All the data presented are archived by the Marshall Space Flight Center Environments Group, and were obtained from a combination of surface observations and meteorological towers at Kennedy Space Center (KSC), Florida. Data are provided from the first launch of the STS in 1981 through the launch of STS-107 in 2003.

2. DATA SOURCES DESCRIPTION

The data in this paper were collected over a period of approximately 23 years at surface observation stations and from meteorological (MET) towers at KSC.

2.1 Surface Observations

Hourly surfaces observations from two sites are included in the archive and used for this report. Table 1 gives the source information, including the station call sign, Weather Bureau Army/Navy (WBAN) designation, World Meteorological Organization (WMO) designation, approximate location with respect to the Space Shuttle Launch Complex 39 (LC-39) and period of record for the archive. The location of these observation stations is shown in Figure 1.

Due to questionable hourly precipitation data from Station 12868, daily precipitation totals as measured at Station 12886 and provided by the Air Force Combat Climatology Center are presented in this document through STS-86 (September 1997). After STS-86, precipitation measured near the pads with optical rain gauges is presented.

The surface observation data in this document were obtained near ground level. Temperature, relative humidity, pressure and precipitation are measured at approximately 1.5 m above ground level. Wind speed and direction are measured at approximately 9 m above ground level.

Table 1. Surface observation data source descriptions

Source	Location	Period of Record
Cape Canaveral Air Force Station (CCAFS) Call Sign: XMR WBAN Station #12868	16 km south of LC-39	12/1980 – 11/1984
Shuttle Landing Facility (SLF) Call Signs: X68, TTS & KTTS WMO Station #74794 WBAN Station #12886	8 km west of LC-39	12/1984 - Present

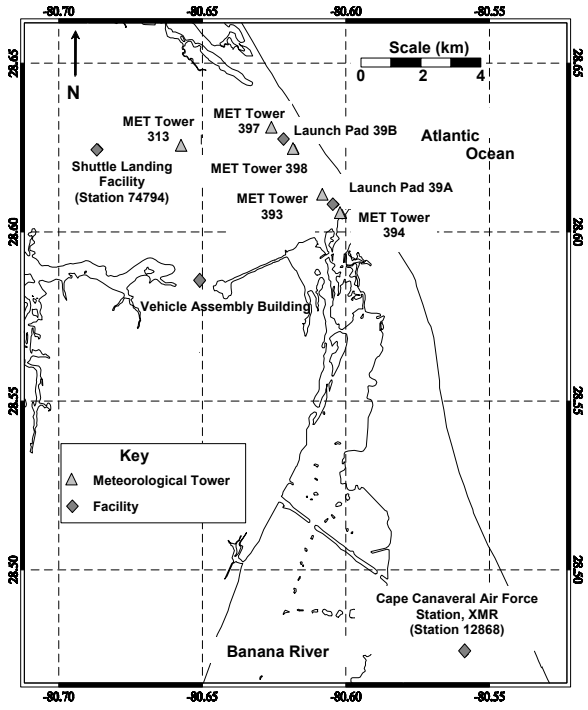

Figure 1. Kennedy Space Center meteorological observation locations

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2.2 MET Tower Observations

Data from six MET towers have been archived by the MSFC Environments Group and are used in this document. Tower 393 is on the northwest side of Launch Pad 39A (LP-39A) and Tower 394 is on the southeast side. Tower 397 is on the northwest side of LP-39B and Tower 398 is on the southeast side. The location of these towers is shown in Figure 1. Each tower is approximately 0.4 km from their respective launch pad.

The wind data from Towers 393, 394, 397 and 398 were measured at 18.3 m above natural grade (ANG). The temperature, humidity and dew point from Towers 393, 394, 397 and 398 were measured at both 1.8 m ANG which is equivalent to approximately 6.4 m above mean sea level (MSL) and 18.3 m ANG. All data from Tower 313 were measured at 16 m ANG because Tower 313 is not instrumented at 18.3 m ANG.

From STS-56 (March 1993) to STS-80 (October 1996), the tower data consists of temperature, dew point, relative humidity, wind speed and wind direction. After this time, pressure measurements were added to Towers 394 and 398 only. The pressure data were measured at approximately 6.4 m above MSL. The measured pressure values were adjusted to sea level pressure to provide a common reference level using the following equation:

$$SLP = P_{\Delta Z}\left(1 + \frac{\Delta Z}{\overline{H}}\right) \qquad (1)$$

Where, *SLP* is sea level pressure, $P_{\Delta Z}$ is the measured (barometric) pressure, ΔZ is the height of the barometer above sea level in meters and $\overline{H}$ is the scale height (8500 m). This equation is a simplified form of the hypsometric equation, Wallace (1977), and is accurate to within about 0.1 hPa for ΔZ less than about 120 m.

After STS-80, optical rain gauges were added to Towers 393, 394, 397 and 398. The optical rain gauges provide one-second precipitation measurements. This data was available only sporadically until STS-87 (October 1987).

3. STS PAD EXPOSURE PERIOD EXTREMES

The pad exposure period extremes for each meteorological parameter are shown in Figures 2 to 6. The overall maximum and minimum are highlighted in the figures. All the extreme parameter values are within the design requirements for the Space Transportation System for the pad exposure period.

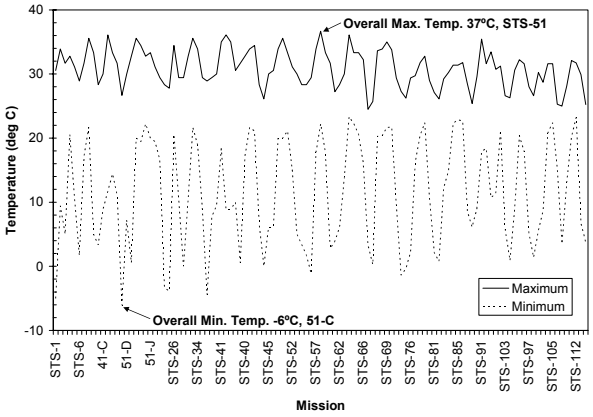

Figure 2. Temperature extremes for all Space Shuttle pad exposure periods.

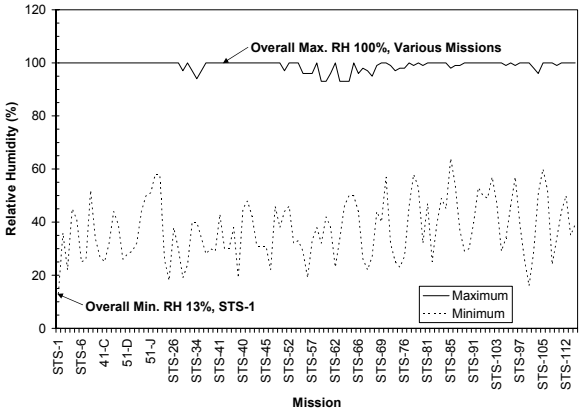

Figure 3. Relative humidity extremes for all Space Shuttle pad exposure periods.

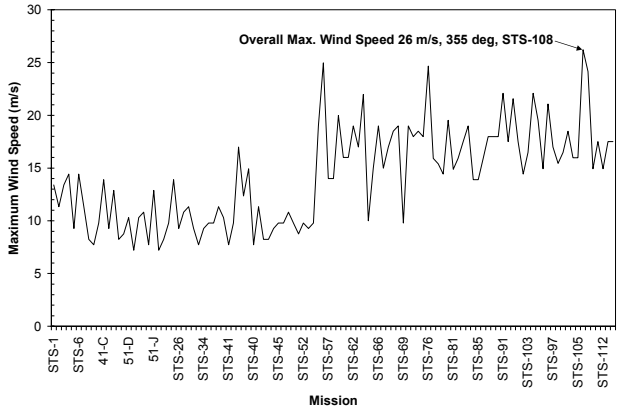

Figure 4. Maximum wind speed for all Space Shuttle pad exposure periods.

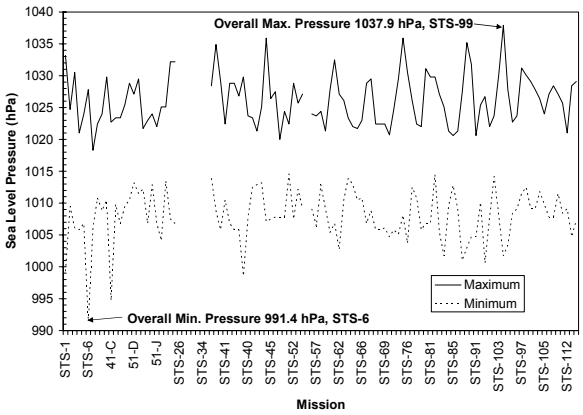

Figure 5. Sea level pressure extremes for all Space Shuttle pad exposure periods.

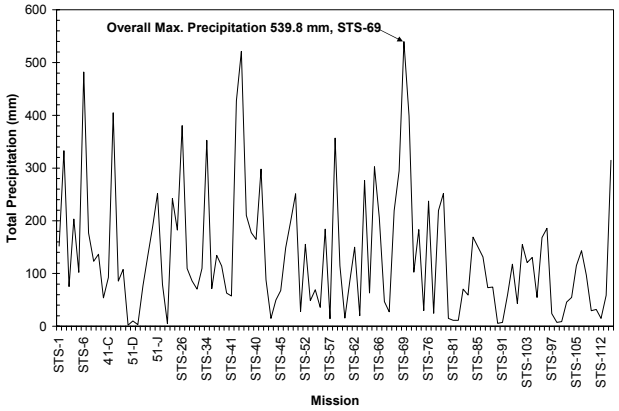

Figure 6. Total precipitation for all Space Shuttle pad exposure periods.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

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