General Characteristics		
1	**Abstract of Model Capabilities**	PAVAN was developed for the Nuclear Regulatory Commission (NRC) to provide atmospheric dispersion conditions for the assessment of the consequences of design basis accidents for nuclear power stations. Such assessments are required under 10 CFR 100 and 10 CFR 50. The PAVAN code implements the guidance provided in Regulatory Guide 1.145, “Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants”. In addition to being used by commercial nuclear licensees, this code has been applied to non-reactor nuclear facilities operated by the Department of Energy (DOE). PAVAN does not calculate doses. Using joint frequency distributions of wind direction, wind speed, and atmospheric stability class, the program provides relative air concentration values as functions of direction for six averaging time periods at the Exclusion Area Boundary (EAB) and the Low Population Zone (LPZ).
2	**Sponsor and/or Developing Organization**	T. J. Bander in 1982, Battelle Pacific Northwest Laboratory for the U. S. Nuclear Regulatory Commission. No other sponsors. No modifications or revisions since 1982.
3	**Last Custodian/ Point of Contact**	Technical support: Leta Brown (Jay Lee, previously) U. S. Nuclear Regulatory Commission Rockville, MD 301/415-1232 Software procurement: Energy Science and Technology Software Center (ESTSC) 423/576-2606; FAX: 423/576-6436
4	**Life-Cycle**	Not descended from any previous software; a first-in-kind methdology implementing the guidance provided in Reg. Guide 1.145. The new methodology includes the reduction in estimated ground-level concentrations due to plume meandering during the occurrence of stable atmospheric stability conditions and light wind speeds, and the recognition that atmospheric dispersion conditions are directionally dependent.
5	**Model Description Summary**	PAVAN is a program developed by PNL for the U. S. Nuclear Regulatory Commission to estimate downwind ground-level air concentrations for potential accidental releases of radioactive material from nuclear facilities, as required by 10 CFR Part 100 and 10 CFR Part 50. The program implements the guidance provided in Regulatory Guide 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants." The code provides relative air concentration (X/Q) values as functions of direction for various time periods at the exclusion area boundary (EAB) and the outer boundary of the low population zone (LPZ) using joint frequency distributions of wind direction and wind speed by atmospheric stability. Calculations of X/Q values can be made for assumed ground-level releases (e.g., through building penetrations and vents) or elevated releases from free-standing stacks. The user may elect various options of the code. The variation in the location of the release points, additional plume dispersion due building wakes, plume meander under low wind speed conditions, and adjustments to consider non-straight trajectories. It can compute an effective plume height using the physical release height which can be reduced by inputted terrain features. PAVAN cannot handle multiple emission sources.
6	**Application Limitation**	PAVAN has been developed to address a relatively narrow range of applications. It should not be applied to complex terrain situations, nor should it be used for real-time emergency response applications.
7	**Strengths/ Limitations**	PAVAN is the baseline model for calculation of site-specific unit air concentration values (X/Q) following the guidance contained in USNRC Reg. Guide 1.145. Radiological doses are not output, but can be obtained with user-added post-processing modules. It is an Eulerian, Gaussian plume model that accounts for calm periods, meander, terrain, release elevation and building wake. Desert (15 to 60 minute sampling times) or Pasquill-Gifford (3 - 10 sampling times) dispersion factors may be used.

8	**Model References**	! PAVAN/Version 2.0 ! Energy Science & Technology Software Center Package ID: 000116I303300 PAVAN ! T. J. Bander, **PAVAN: An Atmospheric Dispersion Program for Evaluating Design Basis Accidental Releases of Radioactive Materials from Nuclear Power Stations**, Pacific Northwest Laboratory, NUREG/CR-2858, PNL-4413 (November 1982). ! U. S. Nuclear Regulatory Commission, **Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants**, Regulatory Guide 1.145 (November 1982 and February 1983). ! Snell, W. G., and Jubach, R. W., **Technical Basis for Regulatory Guide 1.145 'Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants'**, NUREG/CR-2260, (October 1981).
9	**Input Data/Parameter Requirements**	Input includes height of release, height of wind sensors, and heights between which vertical temperature difference was measured. Include the minimum cross-sectional area for structure if the building wake correction model is to be applied. Also, include the : (a) height above plant grade of the containment structure and the height above grade of the release point; (b) the number of hours (or %) of calm for each stability category; and (c) joint freq. data in hours or percent, as [direction, wind speed, stability] vectors. Input downwind distance factors, and site-specific terrain correction factors. Also, the number of wind-speed categories, and the number of distances with terrain data for each sector.
10	**Output Summary**	PAVAN outputs centerline and sector-average X/Q values for six average intervals (1 hour to 1 year) as prescribed in Regulatory Guide 1.145 at two sets of distances, typically the Exclusion Area Boundary distances and the Low Population Zone Boundary distances. For both distance sets, three procedures are utilized for the calculation of X/Q values: ! The direction-dependent approach described in Regulatory Guide 1.145. The JFD used in calculating the X/Q distribution is that which occurs in each downwind sectors. The X/Q in each sector that is exceeded 0.5% of the total time is calculated. ! The direction-independent approach as defined in the Standard Review Plan 2.3.4 model. This option uses the minimum distance of Boundary 1 for the first boundary and the minimum distance of of boundary 2 for the second boundary. Plume meander is not utilized under procedure 2. the frequency distribution of wind speed and atmospheric stability, independent of wind direction, is used for developing the the X/Q distribution. The X/Q value which is exceeded 55 of the total time is calculated. ! The third procedure follows computation of the five percent overall site X/Q approach described in Reg. Guide 1.145. This procedure uses the X/Q values calculated in Procedure One with the frequency of occurrence for each sector to develop a single X/Q distribution for each entire boundary. The X/Q value is that value which is exceeded 5% of the total time.
11	**Applications**	PAVAN provides atmospheric dispersion conditions for the assessment of the consequences of design basis accidents for nuclear power stations. Such assessments are required under 10 CFR 100 and 10 CFR 50. The PAVAN code implements the guidance provided in Regulatory Guide 1.145, “Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants”. In addition to being used by commercial nuclear licensees, this code has been applied to non-reactor nuclear facilities operated by the Department of Energy (DOE).
12	**User-Friendliness**	The PAVAN code is very easy to use.
13	**Hardware-Software Interface Constraints/ Requirements**	PAVAN was originally written in FORTRAN IV for execution on a CDC 7600. The code is currently offered through ESTSC for execution on an IBM 3033 computer using the OS/VS operating system. No PC versions are available through the software center. The supplied sample problems were executed on the ORNL IBM using the FORTRAN H extended compiler and the OS/VS2, and the FORTRAN Gcompiler using OS/VS.
14	**Operational Parameters**	The PAVAN code has satisfactory portability originally as a FORTRAN IV code, written for CDC 7600 execution. Presently, ESTSC quotes IBM 3033 machine and OS/VS operating system requirements. Available through Oak Ridge ESTSC**.**
15	**Surety Considerations**	Documentation is adequate for most users. Review Reg. Guide 1.145, and technical basis document (NUREG/CR-2260) before reviewing User's Manual.
16	**Runtime Characteristics**	The PAVAN code is very easy to use, and takes only a few seconds to execute.

Specific Characteristics		
Part A: Source Term Submodel Type		
A1	**Source Term Algorithm?**	__YES ✔ NO
Part B: Dispersion Submodel Type		
B1	**Gaussian**	✔ **Straight-line plume** __ **Segmented plume** __ **Statistical plume** __ **Statistical puff**
Part C: Transport Submodel Type		
C2	**Deterministic**	Yes
Part D: Fire Submodel Type (Not Applicable)		
Part E: Energetic Events Submodel Type (Not Applicable)		
Part F: Health Consequence Submodel Type (Not Applicable)		
Part G: Effects and Countermeasures Submodel Type (No Information Provided.)		
Part H: Physical Features of Model		
H2	**Release Elevation**	✔ **ground** __ **roof**
H3	**Aerodynamic Effects from Buildings and Obstacles**	✔ **building wake** __ **cavity** __ **K-factors** __ **flow separation**
H4	**Horizontal Plume Meander**	RG 1.145 meander factor.
H7	**Cloud Buoyance**	✔ **neutral [passive]** __ **dense [negative]** __ **plume rise [positive]**
H13	**Temporally and Spatially Variant Mesoscale Processes**	**Urban heat island:** **Canopies:** **Complex terrain (land) effects:** __ **mountain-valley wind reversals** __ **anabatic winds** __ **katabatic winds** **Complex terrain (land-water) effects:** __ **seabreeze airflow trajectory reversals** __ **Thermally Induced Boundary Layer definition** ✔ **seabreeze fumigation** __ **landbreeze fumigation** **Thunderstorm outflow:** **Temporally variant winds:** **High velocity wind phenomena:** __ **tornado** __ **hurricane** __ **supercane** __ **microburst**
Part I: Model Input Requirements		
I2	**Meteorological Parameters**	**Wind speed and wind direction:** ✔ **single point** __ **single tower/multiple point** __ **multiple towers** **Temperature:** __ **single point** __ **single tower/multiple point** __ **multiple towers** **Dew point temperature:** __ **single point** __ **single tower/multiple point** __ **multiple towers** **Precipitation:** __ **single point** __ **single tower/multiple point** __ **multiple towers** **Turbulence typing parameters:** ✔ **temperature difference** __ **sigma theta** __ **sigma phi** __ **Monin-Obukhov length** __ **roughness length** __ **cloud cover** __ **incoming solar radiation** ✔ **user-specified** **Four dimensional meteorological fields from prognostic model:**

Part J: Model Output Capabilities		
J4	**Tabular at Fixed Downwind Locations**	EAB and LPZ boundaries for sixteen compass sectors for 95% direction-independent and 99.5% direction-dependent normalized concentrations. Fumigation X/Q values.
Part K: Model Usage Considerations (See Items 5 - 7.)		