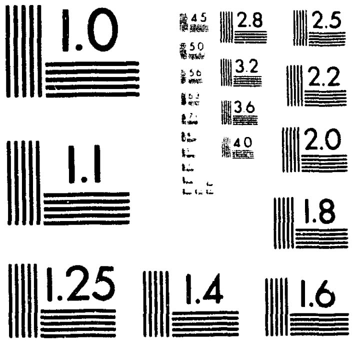
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LIQUEFIED GASEOUS FUELS SPILL TEST FACILITY OVERVIEW OF STF CAPABILITIES

(Short Title: Overview of STF Capabilities)

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ABSTRACT

The Liquefied Gaseous Fuels Spill Test Facility (STF) constructed at the Department of Energy's Nevada Test Site is a basic research tool for studying the dynamics of accidental releases of various hazardous liquids. This Facility is designed to (1) discharge, at a controlled rate, a measured volume of hazardous test liquid on a prepared surface of a dry lake bed (Frenchman Lake); (2) monitor and record process operating data, close-in and downwind meteorological data, and downwind gaseous concentration levels; and (3) provide a means to control and monitor these functions from a remote location.

The STF will accommodate large and small-scale testing of hazardous test fluid release rates up to 28,000 gallons per minute. Spill volumes up to 52,800 gallons are achievable.

Generic categories of fluids that can be tested are cryogenics, isothermals, aerosol-forming materials, and chemically reactive. The phenomena that can be studied include source definition, dispersion, and pool fire/vapor burning. Other capabilities available at the STF include large-scale wind tunnel testing, a small test cell for exposing personnel protective clothing, and an area for developing mitigation techniques.

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In 1982, the U.S. Congress provided funding to build a permanent spill test facility for testing liquefied gaseous fuels and other hazardous and toxic gaseous liquids. The Liquefied Gaseous Fuels Spill Test Facility (STF) was built on Frenchman Flat, a natural geological basin located at the southeast corner of the Department of Energy's (DOE) Nevada Test Site (NTS) 75 miles northwest of Las Vegas, Nevada. The DOE elected to use the Frenchman Flat area because it is uniquely suited in topography, ecology, and meteorology for the testing of hazardous and toxic materials. The favorable meteorological conditions and its remote location enhanced the prospects for siting the facility at the Frenchman Flat area of the NTS. The winds are relatively consistent and predictable from April through October. Another reason for the selection of this site was that the area downwind is federally-managed land which is essentially unpopulated with access controlled by the U.S. Government. The STF became fully operational in 1986 and is available for use by industry and governments on a user-fee basis.

The STF consists of two generally separate process systems. The larger and more complex of the two systems is designed to handle cryogenic fluids, such as LNG, while the smaller system is designed for noncryogenic fluids, such as ammonia, that are normally stored and shipped as pressurized liquids. Thirty-one different chemicals are currently permitted for tests at the site.

The STF has the capability to test phenomena such as source definition, dispersion, rapid phase transition, pool fire, and vapor burn. The facility is also fully capable of providing test sites for mitigation techniques and has remote sensing and computer facilities for collecting data for validation of mathematical models of spill and plume behavior. On-site facilities include a tank farm, wind tunnel, spill pad, meteorological/camera towers, the control building, and the personnel/safety equipment building.

One feature of the STF is the large-scale test area which is represented by the Tank Farm. This capability includes the nitrogen storage and supply system that provides drive, cool-down, and purge gas to the large-scale spill test area. The cryogenic spill system consists of two 100-m^3 (28,000-gal) cryogenic storage tanks connected to 152-m (500-ft) long spill pipes that lead to the spill area. Test fluid is pressure-driven out of the storage tanks and through the spill pipe(s) by means of 120-psi nitrogen drive gas supplied from a 2,000-psi, 67-m^3 (2,400-ft^3) pressure vessel. The source of this gas is an LN_2 storage tank provided with a vaporizer and pumping system. The noncryogenic spill system includes a 90-m^3 (26,000-gal) storage tank connected to the 152-m (500-ft) long spill pipes that are utilized in common with the cryogenic system. Discharge from the storage tank is driven by 280-psi nitrogen gas from the 2,000-psi pressure vessel.

To obtain cloud dispersion data, an array of experimental diagnostic sensors will be placed downwind from the spill point. This array may consist of up to 20 anemometer stations to gather wind-speed and wind-direction data, up to 41 sensor stations to gather data from a large variety of sensors at various levels above ground, and a photographic and meteorological tower. The sensors deployed at the sensor stations include assorted instruments to measure gas concentration (including infrared absorption), humidity, heat flux, aerosol characteristics, turbulence (sonic and bivane anemometers), and flame speed. The sensor array and the associated data acquisition system are linked to the control point by means of telemetry or fiber optics.

The operation and performance of the Facility is controlled and monitored from a remote data-recording control point located one mile from the Spill Facility's process systems location. The basic Spill Facility is configured to accommodate the bulk of what is considered the most common type of testing. The Facility systems are capable of discharging specified quantities of test fluids at a fixed point under the general conditions and within the parameters listed below.

Spill surface	Prepared for the specific fluid to be tested
Dispersion surface	Flat

Wind speeds	Calm to 15 m/s
Test hours	Daylight
Aborting procedure	Spill-valve closure. Test fluid will be drained or vented from the spill pipe(s) after test abort. No provision is made for fluid recovery from pipe(s) into storage tank(s)
Access to sensor array	Until shortly before test

Operating criteria appropriate for the two general categories of test fluids are given in the following tables. All fluid parameters given are in liquid phase and represent the total capacities of the process systems. Depending on the toxicity of the test fluids, environmental constraints might require that the maximum spill volumes be reduced to some level below these capacities. Such tests are scaled down to a level that will accommodate a conservative interpretation of applicable environmental constraints.

Table 1 shows the performance levels for spill tests involving those cryogenic fluids the system is designed to accommodate. Mass flow rates shown represent the throughput in the separate spill lines at maximum and minimum spill rates. Intermediate flow rates are not shown.

Table 2 lists performance-level requirements for the various noncryogenic fluids the Facility is designed to handle. Although only maximum flows are shown, the process control system is capable of handling lower flow rates to accommodate the varying levels of toxicity associated with some of these liquids.

The design-basis process-systems' capabilities shown in Tables 1 and 2 for the test fluids listed are available to support a selected series of spill tests of interest. Although the Facility is designed specifically for the fluids listed, it will accommodate other materials with similar physical properties.

Table 1. Design Basis—Cryogenic Test Fluids

Stream No.[c]	Test Fluid	Test Fluid Conditions				Spill Volume/Mass[a]		Spill Rate[b]	
		Temp. (°F)	Pressure (psia)	Density (lb/ft^3)	Viscosity (cP)	Minimum (lb)	Maximum (lb)	Minimum (lb/min)	Maximum (lb/min)
1 3	Ammonia	–32	13.2	42.7	0.27	7,540	301,600	7,540	75,400 75,400
1 3	LNG (A)[d]	–261	13.2	26.8	0.12	4,730	189.200	4,730	47,300 47,300
1 3	LNG (B)[e]	–259	13.2	27.9	0.15	4,930	197,200	4,930	49,300 49,300
1 3	Ethylene	–158	13.2	35.6	0.17	6,290	251,600	6,290	62,900 62,900
1 3	LPG, Propane	–48	13.2	36.3	0.22	6,410	256,400	6,410	64,100 64,100
1 3	LPG, Butane	27	13.2	37.8	0.21	6,675	267,000	6,675	66,750 66,750

[a]The minimum spill volume/mass for all fluids listed is 5 m^3 (177 ft^3 or 1,320 gal), and the maximum is 200 m^3 (7,063 ft^3 or 52,800 gal).

[b]The minimum and maximum spill rates for all fluids listed are, respectively, 5 m^3/min (177 cfm or 1,320 gpm) and 100 m3/min (3,531 cfm or 26,400 gpm).

[c]Streams 1 and 3 were used in parallel for maximum flows.

[d]Pure methane.

[e]Mixture of 92% methane, 6% ethane, and 2% propane.

Table 2. Design Basis—Noncryogenic Test Fluids

Stream No.[c]	Test Fluid	Test Fluid Conditions				Spill Volume/Mass[a]		Spill Rate[b]	
		Temp. (°F)	Pressure (psig)	Density (lb/ft^3)	Viscosity (cP)	Minimum (lb)	Maximum (lb)	Minimum (lb/min)	Maximum (lb/min)
1 3	Chlorine	100	155	84.4	0.31	8,940	268,220	5,960	29,800 29,[illegible]
1 3	Nitrogen Tetroxide	100	31	87.5	0.34	9,270	278,075	6,180	30,920 30,920
1 3	Hydrazine, anh.	100	<1	61.9	0.8	6,560	196,715	4,370	21,860 21,860
1 3	LPG, Propane	100	187	30.0	0.1	3,178	95,340	2,119	10,600 10,600
1 3	LPG, Butane	100	52	34.9	0.16	3,697	110,910	2,465	12,320 12,320
1 3	Cyclohexane	100	3.3	47.4	0.74	5,022	150,635	3,348	16,740 16,740
1 3	Ammonia	100	212	36.4	0.13	3,856	115,680	2,570	12,850 12,850

[a]The minimum spill volume/mass for all fluids listed is 3 m^3 (106 ft^3 or 792 gal), and the maximum is 90 m^3 (3,17a ft^3 or 23,775 gal).

[b]The minimum and maximum spill rates for all fluids listed are, respectively, 2 m^3/min (71 cfm or 528 gpm) and 20 m3/min (706 cfm or 5,280 gpm).

[c]Streams 1 and 3 were used in parallel for maximum flows.

The STF site also contains a smaller scale spill test area represented by two new facilities built by industrial site users during 1988: the wind tunnel and spill pad. The wind tunnel is designed to test variable spill rates and volumes in a working chamber 2.4 m (8 ft) wide by 4.9 m (16 ft) high and 29.3 m (96 ft) long. The tunnel is equipped with a variable speed induced draft fan and can, within limits, be configured to allow for temperature and humidity conditioning of the draft by use of steam and/or water nozzles placed in the air intake upstream of the test fluid entry point. Spill pads are a 4.57 m × 4.57 m (15 ft × 15 ft) concrete pad with a 2.1 m × 2.1 m (7 ft × 7 ft) spill plan that can be placed on it. An additional use of the pads is to provide hazmat crew training and mitigation technique testing with small-scale spills of less than or equal to .38 m^3 (100 gal). The hazardous chemical small scale spill capability also has the ability to perform totally-encapsulating protective TECP suit tests.

The Spill Test Facility is equipped with a computer based Command, Control, and Data Acquisition System (CCDAS). The CCDAS building, located approximately one mile distant and up-wind of the spill site, is the overall control center for the STF and provides remote and local control; monitoring important parameters and status information within the process system; and recording data from the data acquisition system. It has been designed to enhance safe operation and, although it is located remote from the spill site, can provide automatic shutdown if a critical out-of-range condition is detected—such as failure of a pressure regulator. Through a high-speed data link, operators at the CCDAS may observe and control a spill, as well as acquire diagnostic data from the sensor array, meteorological towers, photographic stations, and user-supplied portable sensor stations, all in real time.

Data are gathered and recorded utilizing the Liquefied Gaseous Fuels Data Acquisition System (LGFDAS) which consists of a general purpose portable array of remote monitoring stations. The portable sensors are solar-battery powered and are linked to the control point by telemetry. The monitoring computers for LGFDAS telemetry are located in the CCDAS building and there are over 400 channels available to the LGFDAS to measure and record user identified parameters such as gas concentration, humidity, heat flux, aerosol characteristics, turbulence, and flame speed. Test sponsors may augment the facility's data acquisition systems to meet particular testing needs.

In conclusion, the heightened world-wide attention regarding environmental, health, and safety issues demands a better understanding of the risks associated with hazardous materials use, handling, and transport. The U.S. DOE's Liquefied Gaseous Fuels Spill Test Facility provides a unique opportunity for industry and governments to significantly expand such knowledge through large- and small-scale testing, development of necessary models and background information, and performing release prevention and control assessments. In addition, the testing facilities and the data which have been generated as a result of the tests performed at the Facility have enabled sponsors to address safety and health concerns at their sites and surrounding public areas by implementing mitigation measures developed at the STF.

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