Validation of PHAST and SAFETI for LNG

The validation of LNG for this scenario is described in detail by the downloads available from website
http://www.dnv.com/services/software/products/safeti/safetiqra/phast.asp

Furthermore it is described in detail for the several different models by the extensive validation included on the PHAST/SAFETI reference CD (UDM dispersion validation manual; validation sections in theory manuals for pool evaporation model PVAP and pool fire model POLF) and this is available to all PHAST and SAFETI users.

PHAST/SAFETI validation is carried out for LNG as follows:

Validation of PHAST/SAFETI dispersion model UDM against LNG dispersion on water: Maplin Sands, Burro, Coyoto (see references below)

Puttock, J.S., Blackmore, D.R.,, Colenbrander, G.W., Davies, P.T., Evans, A.. Homer, J.B., Redfearn, J.J., Vand 't Sant, W.C. and Wilson, R.P., "Spill tests of LNG and refrigerated liquid propane on the sea, Maplin Sands, 1980: experimental details of the dispersion tests", TNER.84.046, Shell Research Ltd., Thornton Research Centre, Combustion Division (1984)

Koopman, R.P., Baker, J., Cederwall, R.T., Goldwin Jr.,, H.C., Hogan, W.J., Kamppinen, L.M., Klefer, B.D., McClure, J.W., McRae, T.G., Morgran, D.L., Morris, L.K., Spann Jr., M.W., and Lind, C.D., "Burro series daeta report, LLNL/NWC 1980 LNG Spills Tests, UCID-19075, Lawrence Livermore National Laboratory, Livermore, California (1982)

Goldwire, H.C. Jr,. Rodean, H.C, Cederwall, R.T., Kansa, E.J., Koopman, R.P., McClure, J.W., McRea, T.G., Morris, L.K., Kamppinen, L, Klefer, R.D., Urtlew, P.A., and Lind, C.D., "Coyote Series data report, LLNL/NWC 1981 LNG Spill Tests: dispersion, vapour burn, and rapid phase transition, UCID-199953, Lawrence Livermore National Laboratory, Livermore, California (1983)

Validation of PHAST/SAFETI pool evaporation model PVAP: experiments by Reid and Wang (boiling of LNG on concrete), experiments by Burgess et al., ESSO, and Koopman et al. (LNG pools on water)

Reid, R.C., and Wang, R., Cryogenics (July 1978), pp. 401-404 (1978)

Burgess, D.S., Murphy, J.N., and Zabetakis, M.G., "Hazards of LNG spillage in marine transportation", SRC report No. S-4105, US Dept. of Interior, Bureau of Mines (February 1970a)

Feldbauer, G.F., Heigl, J.J., McQueen, W., Whipp, R.H., and May, W.G., Spills of LNG on water –vaporisation and downwind drift of combustible mixtures, Report No. EE61E-72, Esso Research and Engineering Company (1972)

Koopman, R.P., Bowman, B.R., and Ermak, D.L., Data and calculations of dispersion of 5 m^3 LNG spill tests, Lawrence Livermore Laboratory

Validation of PHAST/SAFETI pool fire model POLF against experiments by Johnson (Shell experiments) and Nedelka et al. (Montoir experiments)

Johnson, A.D., "A model for predicting thermal radiation hazards from large-scale LNG pool fires", IChemE Symp. Series No. 130, pp. 507-524 (1992)

Nedelka, D., Moorhouse, J., and Tucker, R.F., "The Montoir 35m diameter LNG pool fire experiments", Proc. 9th Int. Conf. on LNG, Nice, 17-20 Oct. 1989, Publ. by Institute of Gas Technlogy, Chicago, Vol. 2, pp. III-3, 1-23 (1990)

In addition to the above we have also carried out significant further validation and verification for LNG against models from Gaz de France for a wide range of scenarios with very positive results. This work was funded by Gaz de France. This involved 12 cases typical of an LNG receiving terminal safety study. This included the following types of LNG releases:

full-bore rupture and partial leaks for sub-cooled LNG pipelines
leaks for pressurised and un-pressurised LNG tanks
full-bore rupture and partial leaks for natural-gas pipelines
release of natural gas inventory in a LNG tank following the activation of a relief valve

This included modelling of discharge, dispersion, jet fires and (in case of rainout) pool fires, and involved examining and comparing LFL distances and radiation distances between PHAST and a extensively validated Gaz de France package. Overall very good agreement was obtained. Thus this gives significant confidence for the PHAST models. Note that this work is confidential and I am therefore not able to provide any further details on this.

Range of LNG validation of models and modelling of extrapolation beyond this range

See the above references for further details on the range of spills that the models are validated for. For dispersion validation, LNG spills range from 6-39 m^3 LNG onto water (Burro/Coyote/Maplin Sands). For LNG pool fire validation (on land) pool diameter ranges were between 1.8 meter and 35 meter.

We have released March this year at the ASSE-MEC Conference in Bahrain, a paper on LNG validation comparing a range of LNG validation studies published in the literature for large marine LNG releases (see attached .pdf file):

Baik, J., Raghunathan, V., and Witlox, H., "Consequence modelling of LNG marine incidents", pp. 92-97, ASSE-MEC 7th Professional Development Conference, Bahrain, 18-22 March 2006

This compares the results of these models for large-scale releases where pool diameters are up to ten times as large as the above 35 meter. Given the current absence of experimental data, this is believed the best type of PHAST verification which could be carried out to obtain confidence about the accuracy of PHAST extrapolation to larger sizes.

Ongoing activities on LNG validation

In DNV we are continuously extending our model validation dataset for our models which includes validation for LNG.

In conjunction with Cardiff University we have currently plans to carry out scaled experiments for two-phase flashing jets with emphasis on the initial droplet atomisation. In the summer this year we kicked of a joint industry project on improved droplet modelling, and LNG experiments may be included as part of this in case we find sufficient sponsors.

In addition to the above, we always try to account of new experimental data as soon as they are published provided they appear to be of sufficient high quality and of use for our model validation.