MINUTES OF MEETING

FLACS User Group (FLUG) meeting

Venue: London, UK

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List of participants

Name	Company
Bob Brewerton	Inoventec Ltd.
Chris Savvides	BP
Cristina Zuliani	Saipem
Dave Price	Gexcon UK
Djurre Siccama	Gexcon AS
Francesco Chille	FC Solutions
Graham Morrison	Gexcon UK
Helene Hisken	Gexcon AS
Johnathan Green	BMT
Kjell Svellingen	Gexcon AS
Kristin Rygg Haugland	Safetec
Lee Phillips	Shell Global Solutions
Louise Black	Gexcon UK
Minoru Jimma	JGC corporation
Olav Sæter	Statoil ASA
Pablo Giacopinelli	Gexcon UK
Paul Michael Cronin	DNV-GL
Prankul Middha	Abercus
Ranveig Niemi	Safetec
Robert Melville	Atkins

Name	**Company**
Steve Howell	Abercus
Steven Betteridge	Shell Global Solutions
Tim Jones	MMI Engineering
Torstein Boge	Gexcon AS
Vincent Tam	Warwick University

FLUG meeting 28-29 November 2017

FLUG chairman: Olav Sæter (Statoil)

Day 1: Tuesday 28 November 2017

Welcome

Kjell Svellingen (Gexcon Software) welcomed the participants to the FLUG meeting. He presented the new test facility that Gexcon has acquired at Sotra, outside of Bergen.

Agenda

Olav Sæter (chair) presented the agenda for the meeting.

Technical Q&A from the FLUG Meeting in Bergen

Torstein Boge (Gexcon Software) gave an update on the issues raised at the previous FLUG meeting in Bergen. He explained that the Ewan-Moodie pseudo source model is included in the coming FLACS 10.7 release, and that Gexcon believes that it will solve the issue regarding low momentum from the jet utility program in FLACS. Prankul Middha (Abercus) asked how the model will be made available to the user. Djurre Siccama replied that both the Ewan-Moodie and original single shock wave models will be provided and are user selectable. For dispersion simulations the original single shock wave has been kept as the default model, whereas for fire simulations the Ewan-Moodie model is now default.

Furthermore, Torstein mentioned that Gexcon considers estimating confidence intervals according to the approach proposed by FDS, but that it will require further population of the validation framework. This development is most relevant for Flacs-3. Vincent Tam (Warwick University) commented that confidence intervals based on validation cases would only be valid for very similar applications. Helene Hisken (Gexcon Software) replied that separate confidence intervals indeed must be defined for the different validation categories.

There was a general discussion on the definition of a parameter to characterise the congestion density of a geometry model in FLACS. Helene commented that based on validation for gas explosions, the drag area per m^3 may be a more physically sound parameter to investigate than length per m^3.

Gexcon R&D: Activities and prospects

Helene Hisken (Gexcon Software) presented on-going R&D activities at Gexcon, the main goals for 2018, and prospects for new functionality in the Flacs solver.

Helene presented the current status of Flacs-3 with respect to verification and validation. She explained that due to recent model improvements that changed the results significantly, the beta-version of Flacs-3 that was planned for release at the end of 2017 would be postponed to 2018. The version of Flacs-3 that includes the turbulence- and combustion models developed as part of JIP MEASURE will be released for external testing as soon as the model system has undergone another round of verification, validation and optimisation. Helene explained that before any commercial release, Gexcon would document that the model performance is acceptable for a well-defined set of validation cases from Gexcon's database.

Chris Savvides (BP) commented that Gexcon should investigate the performance for separate validation cases and understand the physical mechanisms generating overpressure in each case. Helene answered that this is an integrated part of Gexcon's validation methodology. Vincent Tam (Warwick University) pointed out the importance of scaling: how will Gexcon know that their results are valid for the large-scale, realistic geometries encountered in industry? Helene replied that Gexcon can only validate the model for the experimental data that are available, and ensure that the physical phenomena are well represented. Scaling effects will be investigated on the scales for which experimental data exists. Vincent commented that the experimental data for the RPSEA programme would be valuable.

Helene presented the current status of the HySEA project and the objectives of the second experimental campaign. The HySEA project receives funding from the Fuel Cells and Hydrogen Joint Undertaking under grant agreement No. 671461. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme and United Kingdom, Italy, Belgium and Norway.

Finally, Helene presented the current status of the AIRRE and Hy3DRM projects.

Gexcon Application Development: Activities and prospects

Torstein Boge (Gexcon Software) presented organisational changes in the Application Development department, the main activities for 2017 and 2018, and several potential new initiatives.

FLACS v10.7 release

Djurre Siccama (Gexcon Software) gave an overview of the new FLACS v10.7 release.

Prankul Middha (Abercus) and Vincent Tam (Warwick University) enquired whether Gexcon could provide validation of the new pseudo-source model, the Ewan-Moodie model, for dispersion. Djurre answered that this will be addressed. Cristina Zuliani asked whether the Ewan-Moodie model would become the default option for the jet utility in the next release. Djurre replied that this will depend on the outcome of the validation. Rob Melville (Atkins) asked whether the new model would require updated grid guidelines, and Djurre explained that the grid guidelines are unchanged.

Djurre presented the new realistic CAD feature that allows side by side visualisation of the real CAD model together with the FLACS geometry model in CASD. The feature allows for using the real CAD model for visualisation of results in Flowvis. Several people remarked that it looked very useful.

Vincent Tam suggested that calculating differences in volume between imported and original objects could be useful as a screening tool when performing QA of geometries. Francesco Chille (FC Solutions) commented that a warning about which geometry the FLACS solver actually uses may be needed, since the real CAD model is only used for visualisation.

FLACS -Risk v1.1r3 release and future developments

Djurre Siccama (Gexcon Software) gave an overview of the FLACS-Risk tool. Olav Sæter commented that FLACS Risk looks very promising, and that it has a great potential for reducing the risk of human error in projects.

FLACS-Fire: Status on deluge modelling

Djurre Siccama (Gexcon Software) presented the plans for including deluge modelling in FLACS-Fire. Vincent Tam (Warwick University) commented that whenever a simplified model is used, high-quality validation data is needed.

Olav Sæter (Statoil) asked whether FLACS-Fire includes the effect of cooling from water deluge and the heating of objects due to radiation from the fire. Djurre replied that a simple 1D conduction model is included for heating; this is monitored by panels. Tim Jones (MMI Engineering) asked whether it would be possible to model heat conduction for solid objects, not only walls. Gexcon will consider including this functionality.

Announcement regarding the partnership between Shell and Gexcon

Lee Phillips (Shell Global Solutions) presented the new partnership between Shell and Gexcon, to be officially announced in a press release 30 November 2017. The software products FRED (Fire, Release, Explosion and Dispersion), Shepherd and PIPA are now exclusively licensed by Gexcon for commercialisation external to Shell. Several of the meeting participants commented that the partnership between Shell and Gexcon would be beneficial. Kjell Svellingen (Gexcon Software) informed that FRED, Shepherd and PIPA will be commercially available from 1 January 2018.

Hydrogen: Good, bad and not so ugly

Paul Cronin (DNV GL) presented pros and cons related to the transition to hydrogen as a fuel in dwellings, and discussed the hazard relative to that associated with the use of natural gas.

Future FLACS-Cloud: High performance computing (HPC) services

Djurre Siccama (Gexcon Software) presented FLACS-Cloud, an add-on service for FLACS users with an existing license. FLACS-Cloud enables the user to run FLACS on the Edinburgh parallel computing centre's (EPCC) high performance cluster.

Tim Jones (MMI Engineering) commented that it would be useful if one could run jobs on the HPC from the command line or a script. Dave Price (Gexcon UK) emphasised that it would be important to do benchmark tests for the efficiency. Cristina Zuliani (Saipem) enquired whether there would be any restrictions on the number of simulations a user can run simultaneously. Gexcon will follow up on these requests.

Future Flacs-3 solver: Development and release roadmap

Djurre Siccama (Gexcon Software) presented the current status and roadmap for the new Flacs-3 solver. Olav Sæter (Statoil) remarked that the adaptive mesh refinement (AMR) functionality has great potential of increasing the accuracy and efficiency of FLACS results.

Future FLACS v10.8 release

Djurre Siccama (Gexcon Software) initiated a discussion on what the users would want to include in the future FLACS v10.8 release.

Olav Sæter (Statoil) commented that a more intelligent and physically founded parameter than obstacle length per volume is needed for characterising the congestion density in geometries.

Tim Jones (MMI Engineering) remarked that being able to simulate small-scale geometries with finer grid resolutions than currently recommended with FLACS would be very useful. He also suggested that improving the modelling of vent panels is needed for several applications. For example, to be able to model more complex aspects of the opening and closing of panels (lids) during an explosion event, would be beneficial.

Francesco Chille (FC Solutions) asked whether it would be possible to have user-defined features in FLACS, so that users can implement their own sub-routines.

Djurre asked the participants whether they were using the Python APIs for Flowvis and CASD. Tim Jones (MMI Engineering) answered that they were using it, but that it would be helpful with more documentation.

Olav Sæter (Statoil) commented that it would be useful if Flowvis could show line monitors.

Djurre asked the FLUG participants whether it is of interest to perform gas detector studies with FLACS. Olav Sæter (Statoil) replied that CFD is very useful for performing such studies.

Energy centres and multi-occupancy buildings

Pablo Giacopinelli (Gexcon UK) presented a risk study on multi-occupancy buildings using FLACS.

Large-scale onshore QRA using FLACS Risk

Graham Morrison (Gexcon UK) presented a QRA study for an onshore facility that was performed using FLACS Risk. Graham argued that QRA studies are most valuable when performed to answer a specific question, for example to compare the safety level between two alternative designs.

Day 2: Wednesday 29 November 2017

Full scale experimental testing of aerosol filling facilities: experiments and validation

Tim Jones (MMI Engineering) presented an experimental campaign and corresponding modelling work performed with FLACS. The study was conducted to investigate explosion scenarios in gas houses where domestic aerosols are filled with flammable LPG propellants. Tim presented the results from one of these tests, where FLACS over-predicted the overpressures from the experiments by approximately a factor 3.

Francesco Chille (FC Solutions) remarked that partial porosities resulting from the curved walls of the gas house (represented on a Cartesian grid in FLACS) likely affected the results. From the subsequent discussions among the meeting participants, a suggestion was made to model the scenario with a square cross-section enclosure, to investigate the effect of curved walls on the overpressures. Prankul Middha (Abercus) pointed out that there has been limited validation for butane in FLACS. Helene Hisken (Gexcon Software) confirmed that there may be inaccuracies in the modelling of butane and iso-butene (represented by butane in FLACS for the present scenario) in the combustion model. Gexcon will look into these issues, and provide an update for the next FLUG meeting.

Design of protection structures off and onshore and role of FLACS

Bob Brewerton (Inoventech Ltd) presented an overview of the use of FLACS as a tool to provide loading information for design of protection structures such as blast walls and explosion relief panels.

Electric equipment enclosure burst explosion

Francesco Chille (FC Solutions) presented approaches for modelling accident scenarios that can occur as a consequence of electric faults in oil-insulated electrical components. Electric arcs can initiate a pyrolysis reaction in the oil component and lead to violent failure of the enclosure and a release of oil and gaseous products. If an ignition source is available, a secondary explosion event can then occur. Francesco presented two different approaches for modelling the primary explosion: 1) assuming that all the flammables that are assumed to be involved in the explosion event are set in a well-mixed gas cloud at stoichiometric concentration and ambient pressure, and 2) modelling all the flammable components in a well-mixed gas cloud at 100% (pure fuel) concentration with an initial pressure equal to the burst failure pressure of the enclosure. He remarked that the explosion results were very sensitive to the initial turbulence levels, and asked whether Gexcon could comment on this.

Helene Hisken (Gexcon Software) explained that the validation work of the approach for simulating vessel burst in FLACS is very limited. Vincent Tam (Warwick University) suggested to analyse the separate parts of the problem (e.g. vessel burst vs. modelling the effect of initial turbulence). He mentioned that Gexcon should have access to relevant validation data for studying the effect of initial turbulence on explosions. Gexcon will look into the validation database, and provide an update for the next FLUG meeting.

A review of CFD for simulating hydrogen explosions, and how to improve confidence in the approach

Prankul Middha (Abercus) presented an overview of recent developments with respect to CFD modelling of accident scenarios involving hydrogen. He emphasised the need to reduce user dependency of the approach, in light of the results from the first blind prediction study in the HySEA project.

Vincent Tam (Warwick University) asked whether the DDT criterion in FLACS has been updated recently. Djurre Siccama (Gexcon Software) answered that the implemented approach is more or less the same as before, but the criteria for likelihood of DDT (explained in the FLACS User Manual) was updated two or three years ago. There will be increased focus on validation of the DDT criterion in the development and validation of Flacs-3.

Large scale pressurised LNG BLEVE experiments

Steven Betteridge (Shell) presented experiments and modelling work performed by Shell Global Solutions using the consequence model FRED for large scale BLEVEs involving pressurised LNG.

Modelling large LNG pool fires on water

Steven Betteridge (Shell) presented analysis and modelling work (performed by Shell Global Solutions) relevant for large-scale LNG pool fires on water. Steven showed results from an improved version of the consequence model FRED for two large-scale pool fire tests performed by Sandia National Laboratories.

The impact of I-beams on explosion studies

Rob Melville (Atkins) presented a comparison study between different imported objects that are used to represent I-beams in FLACS. He showed that significant differences in explosion overpressures were obtained in a hypothetical case, where an extensive array of regularly spaced I-beams are represented by three (or five) boxes or by a single box object per I-beam. The latter may be the case at early stages in the design of a module. For a realistic geometry where all I-beams are converted to boxes, differences in pressure on the order of 10 % were observed. Furthermore, Rob discussed different parameters to describe congestion levels (length/m^3, area/m^3 and volume/ m^3). He showed that area/m^3 may be a more robust parameter for characterising congestion levels; this value is less dependent on the different representations of the imported I-beams. Rob concluded that quantifying congestion levels in geometries is a useful concept, however, using m/m^3 box congestion statistics to characterise a geometry does not appear to be reliable.

Bob Brewerton (Inoventec Ltd.) commented that Gexcon Consulting has developed some guidelines for how to represent congested geometries in FLACS. Several of the participants remarked that it would be beneficial for FLACS if Gexcon Consulting would share their experiences with the community. Several meeting participants also suggested that the geometry import should include information about the steel structure, so that objects such as I-beams and box-beams can be identified in the FLACS geometry. Djurre Siccama (Gexcon Software) proposed to define a special I-beam object in FLACS.

FLACS user dialogue and FLUG wishes

Djurre Siccama (Gexcon Software) invited the meeting participants to a FLACS user dialogue and input for FLUG wishes.

Rob Melville (Atkins) pointed out that the components in the flash and jet utilities and the cs-file are different, and asked whether these could be made consistent.

Francesco Chille (FC Solutions) remarked that Flowvis5 often crashes when plotting 3D contours. Several other users had also experienced this. Djurre Siccama (Gexcon Software) recommended that users who experience crashes to turn on the log-file option in Flowvis, and send reports to Gexcon.

Tim Jones (MMI Engineering) commented that it would be useful if the wall inside solid buildings in Flowvis5 would be white (i.e. without contours). Djurre answered that this could be obtained by specifying a minimum value.

Pablo Giacopinelli (Gexcon UK) remarked that it would be useful to see monitor points when clip planes are used.

Francesco Chille (FC Solutions) asked whether it would be possible to define more than 8000 monitor points in FLACS. Djurre replied that this may be feasible with Flacs-3.

Tim Jones (MMI Engineering) commented that it would be beneficial if far-field blast predictions could be improved in FLACS. Djurre answered that the introduction of AMR is expected to improve the accuracy of blast wave propagation in FLACS.

It was suggested to have a group discussion session in future FLUG meetings.

Olav Sæter (Statoil) asked whether Gexcon could present an organisational chart of the Software business unit at the next FLUG meeting, to reflect the new structure of the departments. Gexcon will follow up on this.

Venue and date for next meeting

The next FLUG meeting will be held 22-23 May 2018 at Gexcon's new facility at Sotra, outside of Bergen.

Closing

Olav Sæter (chair) summed up some highlights from the presentations and discussions, and closed the meeting.