

MINUTES OF MEETING

FLACS USER GROUP (FLUG)

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FLUG meeting 6-7 November 2014

FLUG Chair: Chris Savvides (BP)

FLUG Meeting – November 6th (Day 1)

Welcome
Chris Savvides (BP) welcomed the participants to BP and opened the meeting

GexCon R&D - Activities & Prospects
Lars Pesch (GexCon) reported the latest news from GexCon's R&D department.
Significant effort was spent on the JIP MEASURE (**M**odelling **E**scalating **A**ccident **S**cenarios and the **U**se of **R**isk-reducing Technology for **E**xplosion Safety). Also, the procedure to obtain approval for LNG dispersion studies for FLACS v10.3r2 by the US Department of Transport is ongoing and has resulted in updated validation results. Some work has been carried out on creating an integral model for jet entrainment in Flacs. This ongoing project should alleviate the time step reduction due to high speed jets.
Lars showed experimental results from the industry PhD project «Investigation of flame instabilities in industrial scale explosions». Fuel-rich propane mixtures have been studied to better understand and model the effect of flame instabilities, which can increase the maximum pressures above what would be expected based on the present equivalence ratio. Chris Savvides (BP) wondered whether the Q9 calculation or concept would have to be updated based on these results. Lars replied that it is possible but that such high-level concepts can only be considered after the lower-level physics modelling has been improved. Olav R. Hansen (Lloyd's Register Consulting) commented during the presentation regarding the rich propane experiments that one should not try to completely explain the effect of the overpressures not being reduced as result of the wrinkling. He identified the external explosion of the fuel being pushed out of the duct as a possible occurrence of the maximum pressure for rich cases, counteracting the weakening due to the higher concentration due to entrained air in this region, which can bring the mixture closer to stoichiometric conditions.
Lars mentioned the current collaborations of GexCon R&D with external partners, including AVEVA and PipeTech.
In June, GexCon hosted the Tenth International Seminar on Hazards, Prevention and Mitigation of Industrial Explosions (X ISHPMIE). With more than 200 participants, 140 papers and several outings, demonstrations etc., the conference was a big success.
GexCon R&D recruited three new people, of which one has begun already and the other two will start in January 2015.
Beyond the recruitment in Norway, GexCon R&D is also opening a centre for testing and validation at the new GexCon office in India.
Olav Saeter (Statoil) enquired how quality assurance will be organised for the work done in India. Erik replied that the work to be done there will be testing and validation, and it will be done in close collaboration and under management of GexCon Norway. Dave Price (GexCon UK) indicated that GexCon Norway has also recently hired a dedicated quality manager.
Further, Olav asked about the status of the validation database mentioned at previous FLUG meetings. Lars replied that a lot of validation was carried out using the new tools being developed in GexCon R&D, but that the gathering into a database has not been started.

FLACS technical Q&A session
In this session, Lars Pesch (GexCon) took up issues raised at the previous FLUG meeting and reported on the findings obtained during closer analysis of the problems and the actions taken.
On the FLUG meeting in May 2014, Henning Lohne (DNV GL) gave a presentation highlighting three issues he had found when working with FLACS. The first one concerned the conversion of I-beams into several boxes by geo2flacs. Lars reported that after the May FLUG meeting, GexCon R&D investigated this problem and identified deficiencies in the geo2flacs pattern matching algorithm to be the cause. This has been improved and the fix was included in FLACS v10.3r1. Depending on the element grouping in the dgn file it can, however, not be guaranteed for all cases that I-beams are imported as such.
The second issue mentioned by Henning were peculiarities of the geometry counting algorithm of the co-file utility. Lars regretted that the decision regarding this issue is that fixing the existing co-file utility is deferred to a rewrite of the tool, according to a new spec to be defined. This development will be

carried out partly under the auspices of the RPSEA project, in which GexCon US devises – among others – new geometric characteristics for oil&gas facilities.
Henning's third problem concerned explosion simulations with very high grid dependency. These occurred in geometries with fixed-distance repeated obstructions. Lars emphasized that these are among the most grid-dependent setups one can find, and while the grid dependency was stronger than expected and desired, it would take significant effort to pinpoint the exact origin and reason for the dependency. Lars reasoned that the research undertaken in JIP MEASURE should lead to improvements that should alleviate the grid dependency in the presented case and that the used geometry presents an interesting test case for the improvements. GexCon has been in touch with Henning regarding the issues.
Also at the previous FLUG meeting, Etienne Guinot (Total) had given a presentation of an explosion study that he repeated with several old versions of FLACS, focussing on the differences in the results. Lars briefly went through the findings and added explanations from GexCon R&D's investigation. First, the results obtained with versions 8.1 and 9.0 are very similar, and this could be expected due to the amount and type of the code changes between these two versions. From version 9.0 to 9.1r3 some differences in the modelling and code were carried out and also these render the differences in the results reasonable, but to exactly relate cause and effect would require greater effort than what is considered appropriate. Lars continued by reminding the attendees of the associated changes in Porcalc and the Flacs simulator in version 9.1r4, when artificial flame folding from overlapping geometry was eliminated. These changes obviously lead to different results for most conditions and to quantify the changes in the results, GexCon started using a suite of ca. 950 simulations at the time, which are now run before each release to check for changes. Lars stressed that results of these analyses have been presented at earlier FLUG meetings. The differences in explosion overpressures presented by Etienne were at the upper end, but within the bounds found in GexCon's studies.
Lars continued to present how GexCon evaluates and presents the differences found with the test suite and referred to the compatibility section in the FLACS User Manual. This spawned a discussion regarding the communication of these results and their impact on the validation; it was emphasized by several participants that a validation document or database is the primary target format for validation results, but a short textual information of changes is a desirable addition.

FLACS v10.3r2
Djurre Siccama (GexCon) talked about the two releases since the previous FLUG meeting, 10.3r1 and 10.3r2. Djurre explained that the timing and content of the two releases was due to the development and delay of the new FLACS-Fire simulator. Apart from that one, a number of other improvements and bug fixes were also included, e.g. regarding CASD stability, Flowvis functionality extensions and bugs etc. Djurre encouraged everyone strongly to install the latest version. He continued by presenting the first attempts to add undo functionality in CASD. Besides the FLACS support contact address, flacs@gexcon.com, Djurre also presented the FLACS LinkedIn group as an interactive channel where many FLACS users and other experts can be reached. It was asked whether it would be possible to link from the FLACS software or documentation to the LinkedIn forum. Djurre replied that GexCon would look into this.
Olav Sæter (Statoil) pointed out that GexCon has to be alert to users' comments in the forum that recommend using FLACS or its results in ways not conforming with the guidelines, validated procedures or application ranges.

HPC – to be continued
Erik Aadland (GexCon) updated the attendees on the collaboration between GexCon and the Edinburgh Parallel Computing Centre (EPCC). He renewed the test offer given at the previous FLUG meeting, interested FLACS license holders can sign up for a free trial period and run a project with FLACS on EPCC's HPC infrastructure by sending a request to flacs@gexcon.com. Erik gave an overview of the different supercomputers available at EPCC and of some aspects the FLACS on-demand service under development. A key aspect of such an offering is security of the data; Dave Price (GexCon UK) added that EPCC's facilities are used in UK government and health sector projects and that EPCC has both experience with handling sensitive data and relevant certifications.
Another question that was raised concerned the license required for using FLACS on the EPCC infrastructure. Erik emphasized that in the testing period the offering is for free, participants are only required to report their experiences. When the commercial service becomes operational, initial plans are to add a small additional fee per cpu-hour above EPCC's rate is expected, assuming that the client holds a FLACS license already.

Olav Sæter enquired whether GexCon had tested if FLACS, when run on the different clusters at EPCC, gives the same results irrespective of the different hardware architectures. Lars Pesch (GexCon) answered that no such tests had been carried out so far, but that no deviations in excess of, for example, the numerical differences between the serial and parallel solver would be expected. GexCon will follow up on this.

Utilising High Performance Computing for FLACS studies

Rohan Samaraweera (GexCon UK) shared some of the experiences GexCon UK has gained while running four large projects on the EPCC Indy cluster. They experienced no major issues and found the system easy to use for experienced Linux users. Rohan presented the workflow used by GexCon UK and highlighted that the payment per cpu hour usually works out quite cheap. Downloading of small and medium-sized data quantities from EPCC works well, but for very large (r3-) files it can become impractical. Important lessons learned during the projects include: (i) data management: only output necessary data, follow quota consumption so that jobs do not fail because of lack of disk space, (ii) data transfer: rsync for master/scenario files, sftp for relevant results, physical transfer (backup disk by courier) for archiving, (iii) scripting: significant work to transfer scripts to Indy, due to package dependencies etc. As plans for the future Rohan mentioned that GexCon will investigate more exhaustively the scalability of the service and the option for cloud-bursting onto a larger machine at EPCC. Also better documentation of FLACS as a service is required and improvements of the queue management system need to be implemented. Overall, Rohan summarised GexCon UK's experience collaborating with EPCC as very positive.

A question regarding the the pricing per cpu hour came up. Rohan could not give an exact number but estimated the cost at a few pence. Erik Aadland (GexCon) pointed out that GexCon will include this cost into a single fee covering also license and storage.

Rune Teigland (Total) asked about the suitability of the hard- and software to run simulations with billions of cells. Lars Pesch (GexCon) replied that the limitations regarding the scalability of the Flacs simulator are so far unchanged and that massive parallelism is achieved by running many simulations simultaneously.

Chris Savvides wondered how to exploit the amounts of data resulting from a probabilistic study. Rohan admitted that they rely heavily on scripts to do the setup and checking.

Ranveig Niemi (Safetec) added some of experiences Safetec had with FLACS during their trial period on the EPCC system. She confirmed that it was an easy shift, given their experience running on Linux clusters.

Finally, Erik Aadland (GexCon) cited an email from Genesis Aberdeen, giving very positive feedback on their tests on Indy.

A comparison of FLACS with CO2 high pressure leak tests

Frederic Pacaud (Total SA) presented a validation study based on the COSHER experiments, a series of large-scale CO_2 releases. The experiments were carried out at Spadeadam and motivated by the rapid development of CSS technologies while the knowledge of the consequences of possible accidents is poor. The tests had different geometries and atmospheric conditions. Simulations were carried out using FLACS, KFX, and PHAST. For some configurations, PHAST gave surprisingly good results, but Frederic emphasized that this was pure chance given the geometry. Both CFD codes underestimate the concentrations. Frederic attributed this to solid CO_2 being blown away by the jets, as indicated by the measured temperatures being under the ones predicted by CFD. Henri Tonda (Total) stressed this point: the effect of the late sublimation is that 100% concentration can still occur at 100 m distance from the release, in spite of dilution along the way; therefore the CFD models are not conservative. Olav Hansen (Lloyd's Register Consulting) commented that using the HEM model should solve this deficiency. Frederic's summarised the main findings as (i) the high-velocity jet is challenging to model with the non-compressible solver, (ii) the shape of the crater is the most influential parameter for the release direction, (iii) the sublimation of solid CO_2 plays a very important role, leading to higher concentrations than predicted by the models in the first 300 m, (iv) terrain is important. As further desirable improvements, Frederic named the representation of atmospheric conditions and unsteady weather conditions.

Olav Hansen (Lloyd's Register Consulting) asked how Frederic had dealt with the challenges regarding the two opposing jets and speculated about the effects of improving the CO_2 model.

Olav Sæter (Statoil) started a discussion on the modelling of single phase releases as either adiabatic or isothermal and how this is done by the different numerical tools.

Djurre Siccama (GexCon) wondered whether GexCon could receive access to the experimental data. Henri answered that this was not straightforward since the data is owned by the JIP consortium but there might be possibilities by a special agreement.

Natural ventilation studies using FLACS

Steve Howell (Abercus) introduced Abercus as an independent consultancy assisting its customers with CFD expertise and he summarised their probabilistic explosion assessment procedures. Steve continued about the role of ventilation studies as input for dispersion simulations and about the ISO15138:2007 ventilation requirements. Particular issues to be discovered in studies regarding local ventilation are stagnant regions. Steve accentuated that FLACS provides velocity predictions, but does not make the local ventilation rate readily available. This may be the reason why local ventilation is most often studied with other tools, e.g. ANSYS FLUENT/CFX, STAR-CCM+, OpenFOAM. Rohan Samaraweera (GexCon UK) commented that his colleague Chris Coffey had done local ventilation studies, but Rohan did not know the details of how these were done. Marie Rennemo Jellum (Lilleaker) reported having used 2D plots for qualitatively identifying stagnant regions. Steve explained the typical approach as solving the flow field (6 equations), then freezing it and solving a single equation either for the local mean age of air or a tracer gas. Steve reported that the two methods usually give quite similar results but discussed unidirectional flow as one exception, where the methods can yield different results. Steve discussed challenges when using FLACS to compute the local mean age of air or tracer gas advection and showed results obtained by the two approaches for varying wind directions and a single module. The global ventilation rate was almost the same for all four directions, but the local ones are generally much lower. Steve mentioned that Abercus works on the FLACS implementation of the tracer gas method as part of a probabilistic explosion assessment and expressed his hope that the new tools (Jump/Flacs-risk) would provide the facility to automate ventilation studies.

Olav Hansen (Lloyd's Register Consulting) suggested some tweaks to get the tracer gas method to work: setting up a high pressure region, dumping the result, putting in the gas, and continuing the simulation. He also pointed out that when thermal effects are included, then twelve air changes per hour are usually not a problem; since one normally has hot surfaces in process areas the global ventilation is most often sufficient. Vincent Tam (Kingston University) seconded this based on earlier results from Shell research.

Estimation of explosion loading on equipment from CFD simulations

Olav Roald Hansen (Lloyd's Register Consulting) gave a presentation on explosion loads and their determination from FLACS simulation results. He started by stating the different forces acting on small objects and described the simplifications made by different guidelines. Olav illustrated how these simplifications can lead to the underestimation of loads. Further, he stressed that not only the magnitude of the load is important but also its duration. He then explained five methods for quantifying the drag by simulations. These methods consistently underpredict the loads. Olav compared the far-field drag results when using the FLACS standard guidelines with the guidelines he had proposed the year before. The latter yield a sharper pressure wave and better results for the drag. Olav drew as intermediate conclusions that the load predictions inside flame zone were significantly underpredicted for the DDT scenario and the load predictions outside flame zone are reasonable using pressure but too low when using the current FLACS guidelines for the time step. He then suggested to use not only the form drag but also the differential pressure to improve the results. To be able to do this, he explained a method to estimate the differential pressures. The results of Olav's method are good for both weak and strong explosions, usually within 10% of the measured loads and durations. For DDT the quality is slightly lower, but that is not a major concern. Olav concluded that the current industry guidelines need improvements and that the method he proposed can result in safer design at lower cost. He offered to send the paper he published on explosion load determination to interested parties.

Ørjan Knudsen (GexCon) commented that for a realistic installation it would be very hard to set up the simulations to determine loads on many pipes.

Olav Sæter (Statoil) challenged whether one would actually be able to process the loads in practical design and suggested that the structural discipline should be involved in this discussion.

Vincent Tam (Kingston University) added that all four examined methods are based on FLACS and wondered whether experimental data was available. Olav answered that such measurements were available from a previous measurement programme.

Impact of artificial congestion on explosion simulations of offshore platforms

Irufan Ahmed (Warwick University, DNV GL) reported on the validation of a method to add artificial congestion to incomplete models of offshore installations. As-built platform models were used for comparison and objects smaller than 6 inches were filtered with geo2flacs to resemble incomplete models. Irufan explained how artificial congestion was added based on the DNV GL congestion database. His validation cases included five different rectangular gas clouds and five ignition locations. The explosion simulations based on the geometries with artificial congestion generally overpredict the maximum pressure compared to simulations with the as-built geometry. Irufan concluded that the homogeneous artificial congestion gives reasonable conservatism in the overpressures and wondered whether more accurate results could be obtained from a more targeted distribution of artificial congestion. He proceeded to show results from corresponding numerical experiments which did not show a consistent trend when using targeted distribution. Irufan made a point that it is important to know what types of objects are to be added, e.g. whether they are mostly flat or square. He summarised that a homogeneous distribution of AC gives a reasonably good and conservative prediction of overpressures.

Dave Price (GexCon UK) commented that for if probabilistic studies the targeted congestion may make a difference. Olav R. Hansen (Lloyd's Register Consulting) agreed with Dave and pointed out that he had seen cases where it was very important to have targeted congestion. It was discussed that that may be true, but that it can be hard to know where to put the artificial congestion.

Marie Rennemo Jellum (Lilleaker Consulting) asked whether it would be possible to repeat the study with removing different parts of the geometry, e.g. just the small cylinders or the boxes.

Use of FLACS in the early design phase of offshore platforms

Ørjan Knudsen (GexCon) presented some thoughts on the use of FLACS early on in the design of offshore installations, when the decision between different concepts has to be made and potential showstoppers need to be identified. The goal of this phase is to move a single concept on to the FEED phase. He illustrated the typical problem, namely that detailed input is required to give good answers. As one lacks this detailed input in the early design phase, conservatism has to be applied, at the cost of accuracy. Ørjan showed a wellhead platform in concept stage as example, with the goal to give a ballpark figure for the risk. He then elaborated the route taken: making a representative geometry model, adjusting the frequencies, determining consequences by running a limited number of scenarios around critical risk values (e.g. 10^{-4} to 10^{-5}), and combining the results to generate a partial risk curve. Apart from a conclusion on the risk, which was moderate to high in the presented case, Ørjan also exemplified typical questions that could be addressed with such studies, e.g. the decision between grated and plated decks. Ørjan concluded that while significant uncertainty is present in such a study, its advantage is to generate fast answers at an early stage.

Olav R. Hansen (Lloyd's Register Consulting) asked about the number of simulations in the given study. Chris Savvides (BP) added he would expect the consultancies to rely more on their experience from similar projects.

Some simple tests with duplicate geometries and implications when using very detailed CAD data

Daniel Mahoney (Atkins Shared Services Facility) started his presentation by asking how to deal with the increasingly detailed CAD data that is becoming available. Its treatment in FLACS can lead to practical problems when handling or visualising the data (e.g. rotating in CASD or Flowvis) and to more fundamental questions, like which parts of a geometry will have negligible impact on explosion results. As an example of such objects with negligible impact, Daniel mentioned duplicates and completely enclosed primitives. To reduce the complexity, Daniel suggested two ways of simplifying the geometry: (i) trimming by element volume, i.e. remove elements whose volume less than a threshold value, (ii) removal of duplicated or fully contained elements. Atkins has developed some in-house tools to filter by volume and to find objects that are completely enclosed within another object. These already significantly reduce the number of objects in realistic CAD geometry data. Daniel highlighted small (some %) differences in the explosion overpressures when adding completely enclosed objects in real geometry studies, even though the volume and area porosities are the same with and without the duplicated object(s). Regarding the filtering by volume, Daniel posed the important question what is sensible to include and what is not. He also wondered whether an I-beam could be represented by a box.

Chris Savvides commented that such simplifications would be detrimental and that the development during the last decades towards being able to include such geometry details has been because they matter to the results.

Djurre commented on behalf of GexCon regarding the undesirable effect of duplicated or fully enclosed geometry on explosion overpressures. It seems to be caused by a wrong attribution in the flame folding factors, but GexCon has to investigate this issue after the meeting since the issue had not been reported earlier.
Olav R. Hansen (Lloyd's Register Consulting) commented that in the geometry simplification one has to be careful not to remove zero-thickness plates since these are used for special purposes.
Steve Howell (Abercus) suggested using comerge, which allows to split up the geometry into many zones and different categories and combining these at co-file level. In this way, very large geometries can be handled.

FLACS in Russia. Step by step
Alexander Agapov (STC Industrial Safety) gave an update on the adoption of safety standards in Russia and the use of FLACS for carrying out explosion safety studies. Alexander identified the conservatism of the approving entities as the main obstacle on the way to new standards and reported that STC Industrial Safety has been involved in the drafting of the new federal law on industrial safety of hazardous production facilities. He hopes that before the end of 2014 the methods will be approved by Rostechnadzor. The law does not mention FLACS directly, but the examples of calculations required by the formal documents were done with FLACS. Alexander presented two FLACS projects carried out in the last two years, one with release of vinyl chloride and one with a gas explosion in a room with relief panels. He continued to propose some ideas that could enhance the promotion and adoption of FLACS in Russia, for example: (i) more flexible price policy, (ii) the FLACS HPC service for remote FLACS calculations, (iii) use FLACS in the education at universities, (iv) translation of important articles, e.g. the validation report regarding LNG, (v) a FLACS reseller agreement. Alexander invited the attendees to the upcoming FLACS training courses in Moscow.

FLUG Meeting – November 7th (Day 2)

The influence on reduced explosion pressure due to the layout of adjacent explosion vent panels and the potential interaction of combustion flow from large silos during explosion relief
Rohan Samaraweera (GexCon UK) presented work done by GexCon UK to study the risks and mitigation of explosion hazards related to biomass power-generation. He gave a short introduction to FLACS-DustEx, which is the variant used for this application. Rohan continued by reviewing the international standards for dimensioning explosion relief panels; these are mostly based on empirical data and give simple and – as Rohan showed – sometimes wrong guidance. Based on the findings of a typical project, he discussed the effects of vent positioning and configuration on the explosion overpressures. Rohan drew the initial conclusion that the distribution of the vent area on a silo has an important effect on the maximum overpressure of explosions. Here the EN 14491:2012 standard is misleading. Rohan pointed out that further work has to be done to validate the findings, both numerically and experimentally. He advertised the Industry PhD position on dust explosion modelling that currently is open at GexCon R&D.
Vincent Tam (Kingston University) commented that it was known that the EN 14491:2012 standard is wrong.

FLUG wishes
Lars Pesch (GexCon AS) chaired the discussion session and kicked off with a few slides on the existing FLUG wishes and informed about other developments in GexCon R&D. Asked for new wishes, Olav R. Hansen (Lloyd's Register Consulting) commented that it would be desirable to be able to receive output for maximum quantities as a summary once at the end of a simulation rather than in every time step. The second issue he brought forward concerned the spinning functionality in 3D views in CASD and Flowvis 5, which should by default be off to avoid the computer from hanging when accidentally clicking somewhere in the window. Also in CASD, when touching the scrollbar in the scenario menu, several things can happen at once, according to Olav. Another problem Olav mentioned concerned the grid definition and geometry handling in CASD when the imported geometry is very far from the origin (e.g. 20 km). Finally, he wished for better guidance on the time step setting for the incompressible solver.
Chris Savvides (BP) returned to the problems with big geometries mentioned by a speaker on the first day. Lars reassured that GexCon would look into possible improvements and he suggested to have a talk on big geometry handling at one of the next FLUG meetings.

Dave Price (GexCon UK) liked the idea presented by Lars to have the bugs and possibly FLUG wishes listed on the internal FLUG page and possibly to add voting to it.
Rohan Samaraweera (GexCon UK) complained that the state of the quick grid utility in CASD is not persisted when closing CASD, therefore one has default values after restarting and reloading a scenario.
Pablo Giacopinelli (GexCon UK) would like to be have better support for positioning objects in CASD with the mouse, and to have a coordinate system in the object window, making arranging multiple objects (or at least clones of one) more efficient.
Vincent Tam (Kingston University) inquired whether GexCon had documentation on FLACS validation conformance with the MEGGE protocol.

Venue and Date for next meeting and new FLUG chairman
Erik Aadland (GexCon AS) thanked Chris Savvides (BP) for his three years as FLUG chairman and suggested Olav Sæter (Statoil) as new chairman for the FLACS User Group. The suggestion was accepted by the attendees. Erik announced the next FLUG meeting, which will be in Bergen, presumably in the week May 4th-8th, 2015. The exact date will be announced as soon as possible. For the autumn 2015 meeting, China Classification Society has invited FLUG to hold the gathering in Beijing. Hongjun Fan (CCS) introduced China Classification Society (CCS) and welcomed the FLACS User Group. Erik will send a poll to the FLUG community to check who could attend a FLUG meeting in China. Dave (GexCon UK) enquired whether the FLUG meeting in China could be scheduled adjacent to another relevant conference in China or Asia.

GexCon training program
Prankul Middha (GexCon UK) presented the directions GexCon's software department will take regarding training in the future. He showed the different offerings available and announced upcoming courses.

FLACS-Fire update
Djurre Siccama (GexCon AS) updated the attendees on the status of FLACS-Fire. He gave an overview of the different studies that it can be used for and mentioned the ongoing and future developments of the fire simulator. Djurre explained the performance of FLACS-Fire in terms of the different models used and exemplified computing time and memory consumption based on practical cases. He covered the practical limitations and explained their relevance for applications. Djurre listed the application areas and showed examples of fire simulations for each area.
Chris Savvides (BP) asked which validation cases have been run with FLACS-Fire. Djurre summarised the validation cases, which include a wide range of scenarios (different gas types, experimental scales, etc.), though few of these are large-scale and highly congested. Olav R. Hansen (Lloyd's Register Consulting) enquired whether the radiation is calculated on panels. Djurre said that that is currently not the case but that monitor points can be used to determine radiation loads near walls etc.

FLACS-Fire training
Djurre Siccama (GexCon AS) gave an introductory course to FLACS-Fire and supported the participants doing practical exercises with the fire simulator.
Olav R. Hansen (Lloyd's Register Consulting) asked whether QDOSE is integrated linearly or as $Q^{4/3}$ dt. Djurre confirmed the latter [see Section 4.7.16.10 "Heat dose: QDOSE" in the FLACS User's Manual].
Olav also enquired whether a three-dimensional ignition region is collapsed in the shortest dimension, as is done for explosion simulations. [A three-dimensional ignition region is collapsed in the shortest dimension only to create the lookup table (ignition assistant) with limiting radius, flame volume and flame area. The actual ignition region is preserved: Flacs will try to ignite all the control volumes where there is ignitable cloud/condition inside the 3D domain. It is doing collapsing only to create the lookup table. The ignition model uses the ignition assistant only under certain conditions (e.g. until the total volume of combustion product is smaller than the last value of flame volume in the lookup table). The side effect of this methodology in fire simulations is to be investigated. A detailed study to investigate this side effect is proposed.]
Another question concerned 3D plotting of radiation contours, and Djurre pointed out that radiation currently can only be output in cells with geometry. In the future, the full flux model will be implemented and allow plotting interpolated 3D isocontours, also in cells without geometry.

Alexander Agapov (STC) wanted to know whether solid surfaces could be ignited by a neighbouring pool fire, but Djurre made it clear that no solid fires can currently be modelled in FLACS.

Closing
Chris Savvides (BP) thanked the participants for the contributions and closed the meeting.