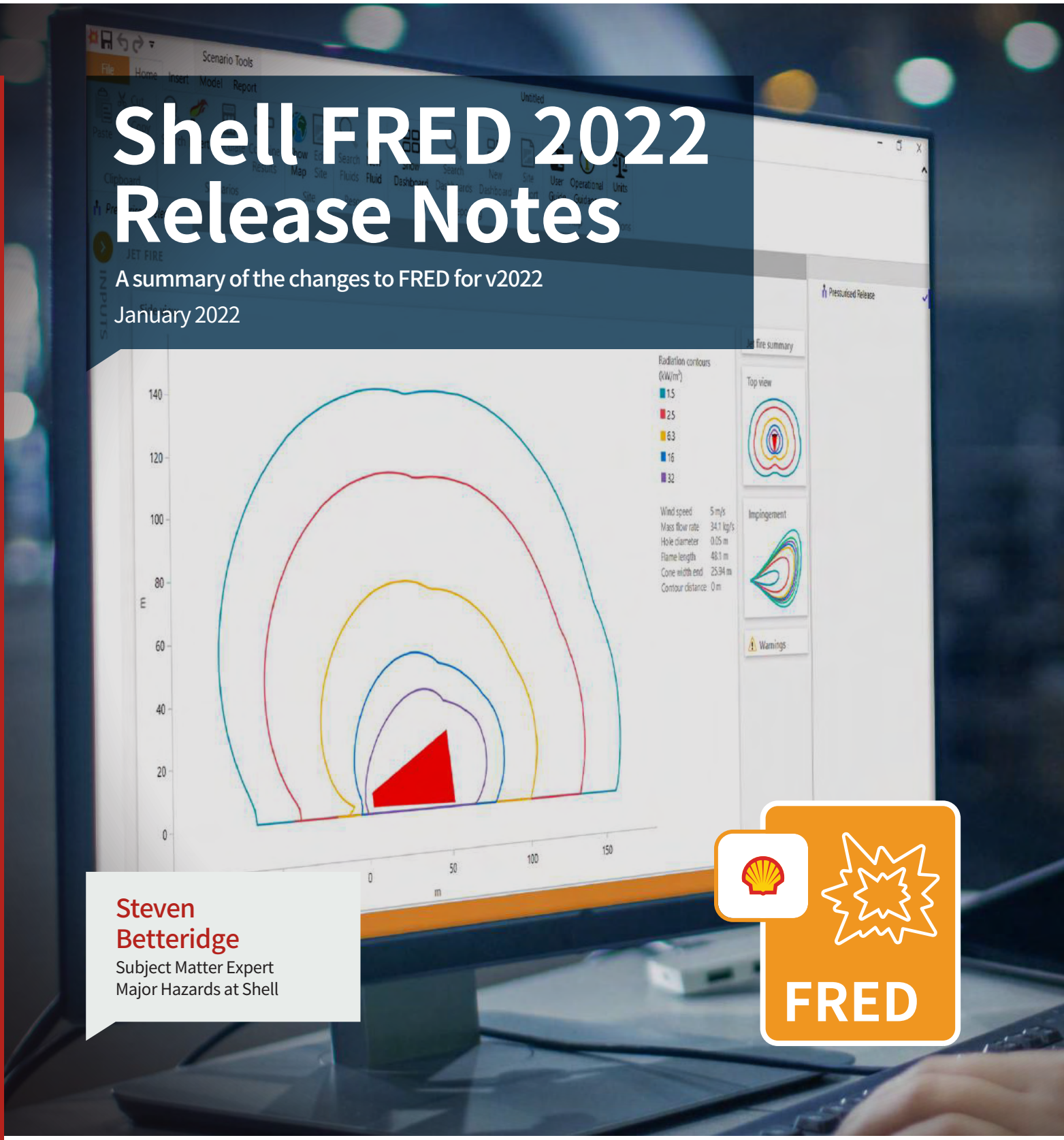
GEXCON
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Shell FRED 2022 Release Notes

A summary of the changes to FRED for v2022

January 2022



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Shell FRED 2022 Release Notes

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Document History

Date	Issue	Reason for Change	Author	Approved by/ Content Owner
14 Jan 2022	1	Release of Shell FRED 2022	Steven Betteridge	Peter Barker

Executive Summary

This release note documents an update to the FRED major hazard consequence software. This update includes four new science models and the migration of four scenarios from FRED 7.1 that did not get migrated to FRED 2020. It also builds upon the updated user interface that was released in FRED 2020 to extend the functionality and usability of the software.

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1. Introduction

This release note documents an update to the Shell FRED major hazard consequence software since the release of Shell FRED 2020 at the start of January 2021. This update includes four new science models:

- Pipe Blowdown
- Missile Fragment (Sub-model of Vessel Burst)
- LNG Flame Impingement (Sub-model of Pressurised Release)
- Transient Pool Dispersion (Sub-model of Unified Scenario)

This update also completes the migration of FRED 7.1, by including the following scenarios that were not in the release of FRED 2020 last year. These scenarios are:

- PRV
- Smoke
- TNO Explosion
- Gaussian Dispersion (continuous, Instantaneous and pool)

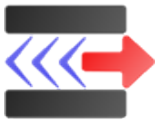
The release of FRED 2022 also includes several enhancements to the user interface, including ability to import images as background to charts, extend unit conversion to all results, greater flexibility to view input/output panels, improved search functionality, extensions to the variant usability, and updated management of custom fluids. There are also several bug fixes within the user interface and associated science models that are also documented in this release note.

2. New Science Models

Four new science models have been implemented into Shell FRED.

Missile Fragment, LNG Flame impingement and Transient Pool Dispersion are sub-models in other scenarios. Pipe Blowdown is a dedicated scenario and effectively replaces a much simpler pipe blowdown model that was available in FRED 7.1.

2.1. Pipe Blowdown Scenario



The pipe blowdown model allows FRED to calculate the release rate (and other quantities of interest) following the full-bore rupture of a long gas pipeline . This differs significantly from the standard situation of a hole in a vessel because the variation in physical properties along the length of the pipeline must be accounted for in order to obtain acceptable results. Specifically, the pressure varies along the pipeline as a function of time, and this make the release more dynamic than a steady state release from a vessel – see Figure 1.

The Pipe Blowdown scenario in FRED is restricted to pipelines containing a gaseous process fluid suffering a full-bore rupture at one end of the pipeline with the other end closed. Where there is a full-bore rupture part way along the pipe, then depending on the failure mode, it is reasonable to assume that the flow rate is the sum of the two components.

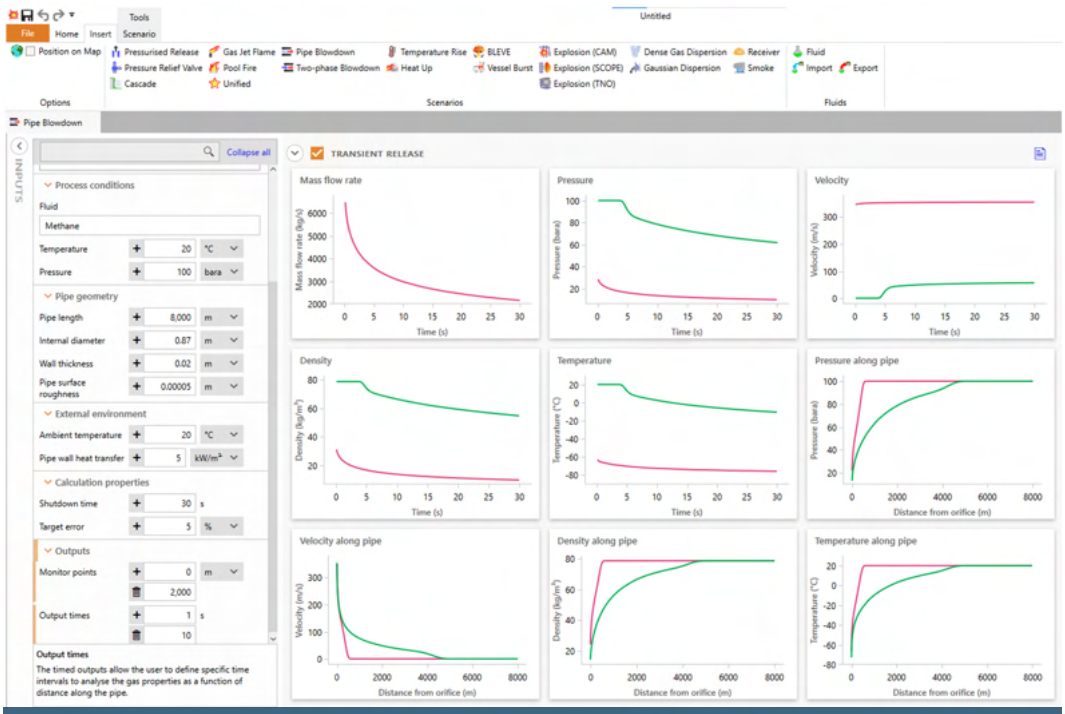


Figure 1: The inputs and results for the Pipe Blowdown scenario

2.2. Missile Fragment model

The missile fragment model has been developed to determine the probability of impact as a function of distance following the catastrophic failure of a vessel. This model has been implemented as a sub-model in the Vessel Burst scenario, as can be seen in Figure 2.

The model itself is based upon an investigation of vessel failures reported in the literature, which was carried out by the University of Bologna for Shell and later published externally. The model itself can be divided into five parts:
(1) Determining the number and fragmentation pattern,
(2) Calculating the initial velocity of each fragment,
(3) Initial direction distribution,
(4) Drag function and trajectory and
(5) Probability of hitting a target of known position and size.

The model displays the probability of hitting a target with a defined size as a function of distance along a radial axis and probability contours for user defined probability levels.

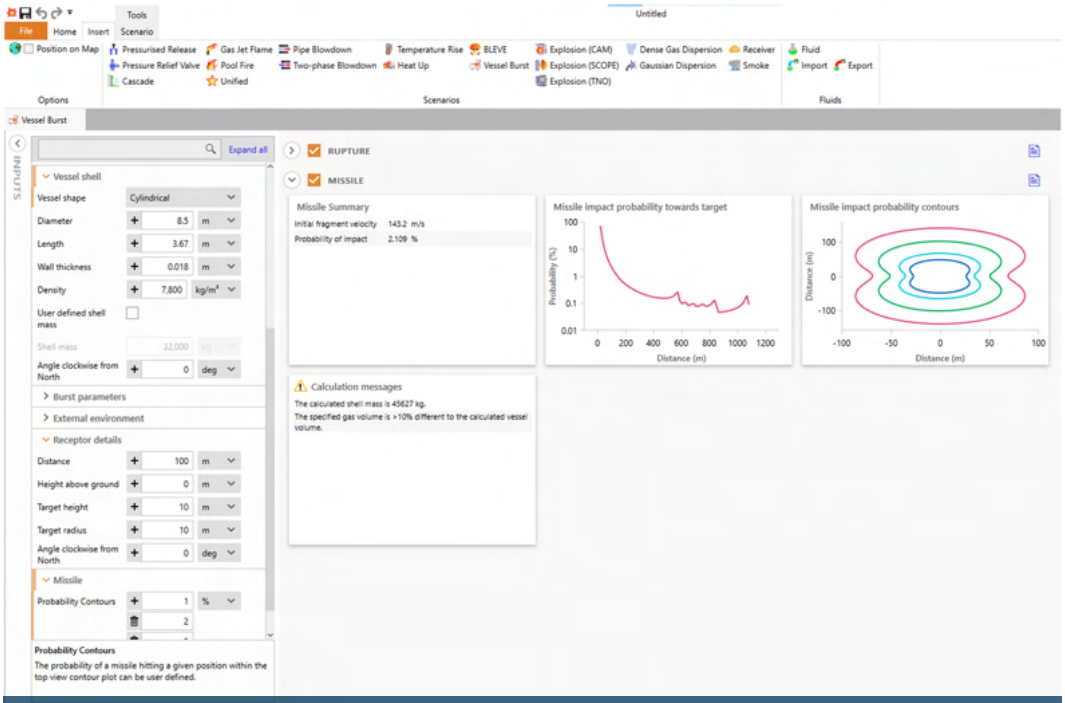


Figure 2: The inputs and results for the Missile Fragment model

2.3. LNG Flame Impingement model

The LNG Flame Impingement model was developed to simulate the flame shape and subsequent thermal radiation following the impingement of a jet fire onto a wall or barrier. It is implemented in the Pressurised Release scenario and is enabled when modelling a release of LNG, as can be seen in Figure 3.

The results of the model indicate the thermal radiation on either side of the barrier e.g. fire wall and can be used to quickly assess the benefits. By performing a sensitivity study on the height and position of the barrier when designing facilities such as LNG terminals.

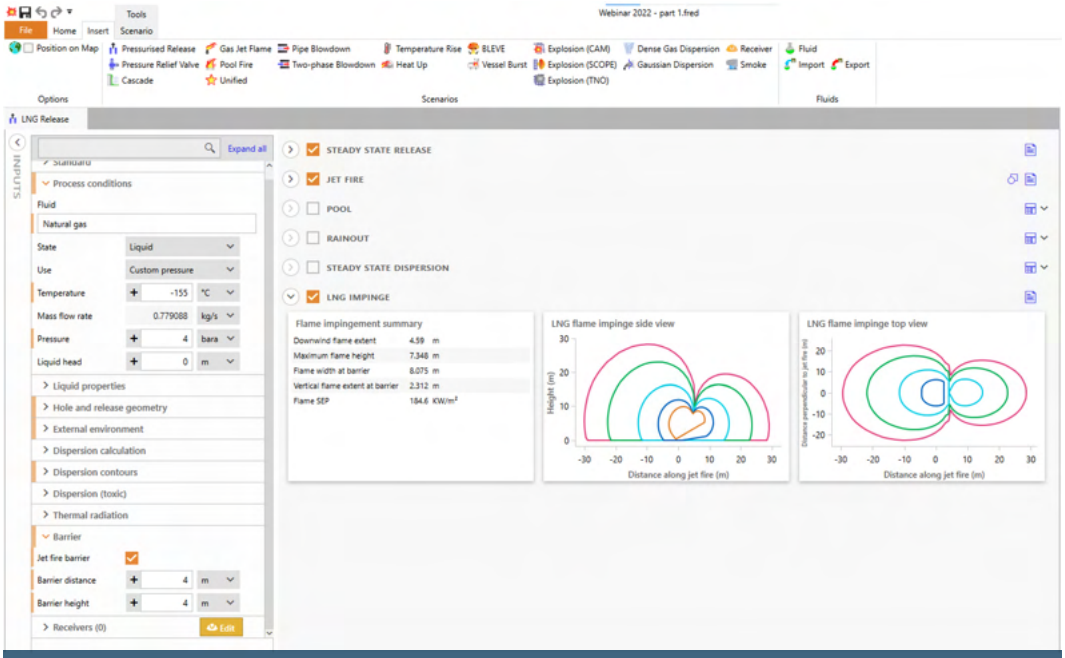


Figure 3: The inputs and results for the LNG Flame Impingement model

2.4. Transient Pool Dispersion model

The transient dispersion model Hegadas-T has been implemented into the Unified Scenario. It uses the transient pool as a source term to calculate the dispersion as a function of time. The model uses the initial vapour composition from the pool, along with the pool area and vaporisation rate for each timestep to define the transient input conditions, as can be seen in Figure 4.

The output results provide a cumulative indication of the concentration as a function of time and distance to enable users to calculate a more representative dispersion distance compared with steady state dispersion.

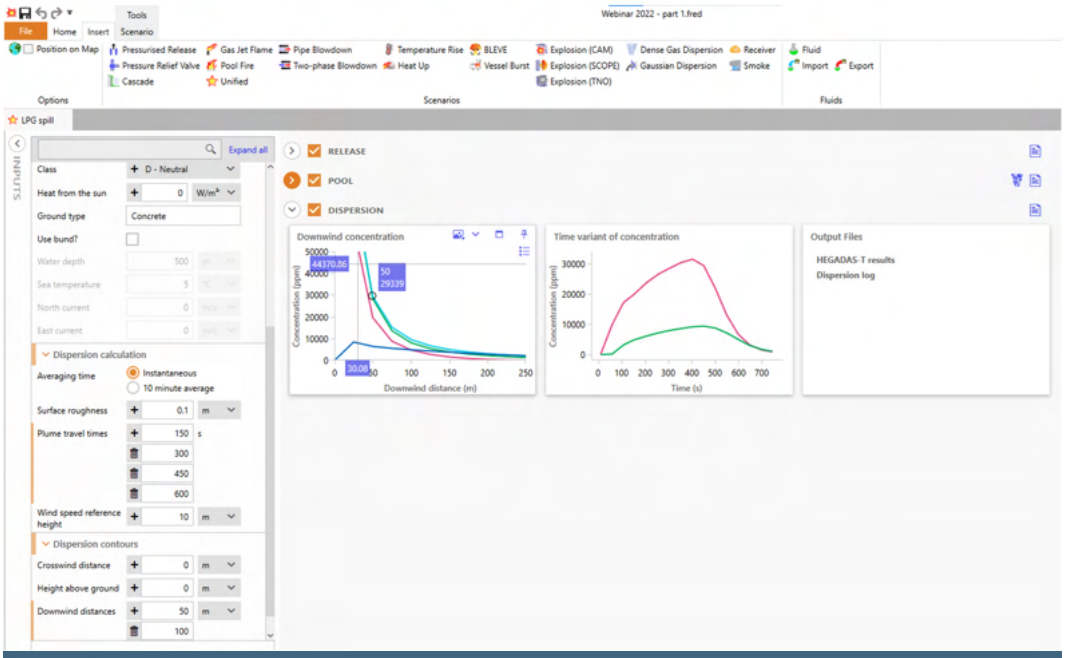


Figure 4: The inputs and results for the Transient Pool Dispersion model

2.5. Improvements to existing models

- Improved the liftoff for slumped jets in momentum dispersion releases by modifying the friction velocity term in the entrainment calculations. This improves the calculation of hydrogen gas clouds near ground and gives more realistic dispersion distances.
- Implemented code in Unified scenario to allow atmospheric releases when the fluid contains up to 10% by weight of vapour. This extends the temperature range of low vapour pressure liquids.
- Reduce the calculation time for atmospheric releases in the Unified Scenario.
- Mixed releases can now be calculated at bubble/dew points.
- Vapour fraction can now be modified and set by the user when modelling mixed releases of single components.
- Improved handling of liquid hydrogen releases near the saturation curve.

3. Migration of Models

The following models were originally available in FRED 7.1, but were not migrated to Shell FRED 2020. Although their user interface has changed (in line with other scenarios in Shell FRED 2022), the core science remains as it was in FRED 7.1 and they will generate the same results.

3.1. Pressure Relief Valve (PRV)



The Pressure Relief Valve scenario models the release of a fluid through single or multiple pressure relief valves on a pressure vessel and calculates the initial release rate of the fluid discharged. Data describing the consequences associated with possible ignition of the discharge are also given, see Figure 5.

The model is for use with Gas/Vapour releases only. The selection of relief valve determines the size of the orifice, and the size of the stack is independent of this. Additional models that are automatically linked are the dispersion suite Aeroplume and PGPlume and the generic jet fire model.

Two-stage modelling assumes choked flow through PRV restriction orifice which cools and slows down. Then the un-choked flow regime in the stack pipe is calculated on basis of exit pressure. The direction of release is always assumed to be vertical.

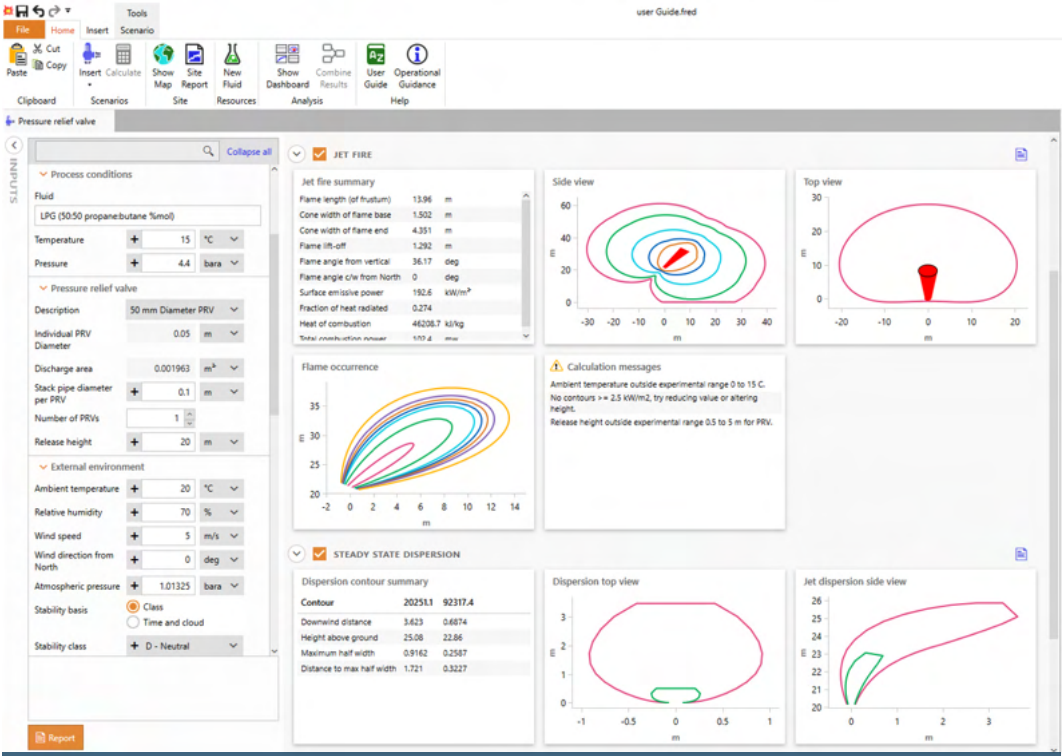


Figure 5: The inputs and results for the PRV model

3.2. Gaussian Dispersion



The Gaussian Dispersion scenario contains three sub-models that were originally separate scenarios in FRED 7.1. These sub-models allow different source terms to be modelled; a continuous release, an instantaneous release and a non-boiling pool release (see Figure 6).

The three models were originally written and published by TNO. They are included in FRED as a backup methodology for the HGSystem dispersion models in the Pressurised Release, Dense Gas Dispersion, Cascade and Unified scenarios, for instance, if requested by a regulator.

The continuous dispersion model has a similar methodology to that implemented to the Shell HGSystem model PGPlume. It is used to model the dispersion for neutrally buoyant gases, released without any momentum, as a function of atmospheric conditions. Similarly, the instantaneous release model is used to model an instant release of a known mass of gas, where the gas is also neutrally buoyant.

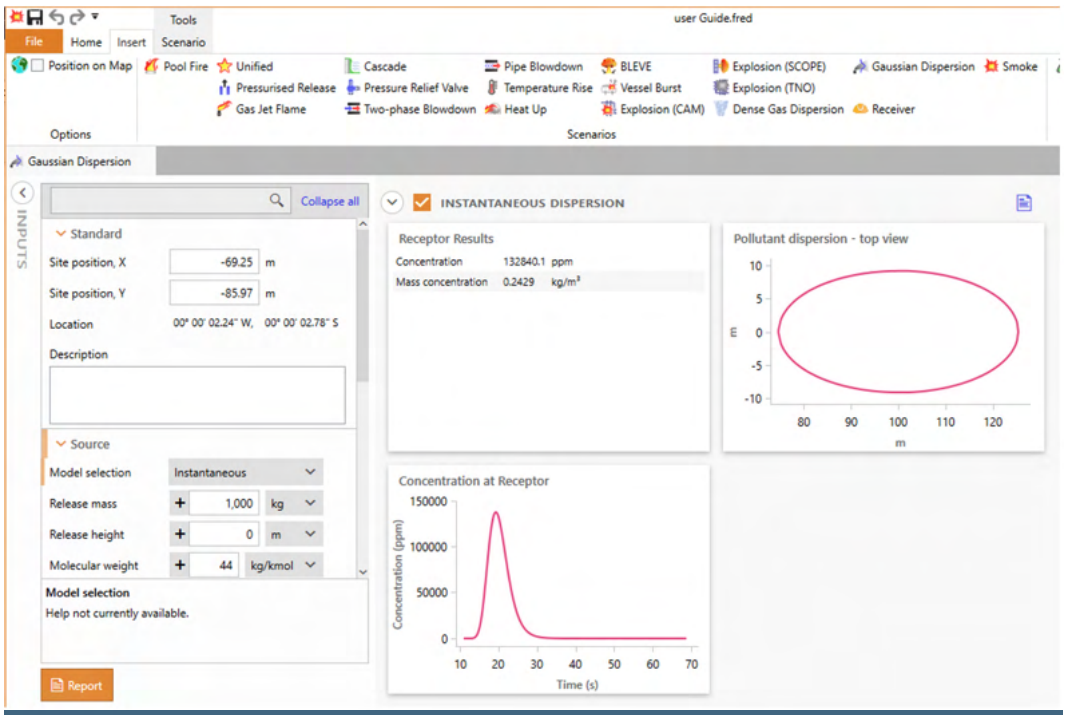


Figure 6: The inputs and results for the Gaussian Dispersion model

3.3. Explosion (TNO)



The Explosion (TNO) scenario uses the multi-energy explosion model that was originally developed in the 1980's to replace the TNT method. It is a considerable advance on the TNT method, because (a) it recognises that the volume of the congested region is important in determining the explosion source and (b) the pressure decay curves given in the method which were computed for an initially acoustic pressure wave driven by an idealised piston. The main difficulty with using the multi-energy method is that it does not provide any means of estimating the pressure generated by the explosion at its source.

The Explosion TNO model is included in FRED 2022 as a backup to the Shell CAM methodology, in case it is required by a regulator or to quickly check results that have been generated in other tools (see Figure 7).

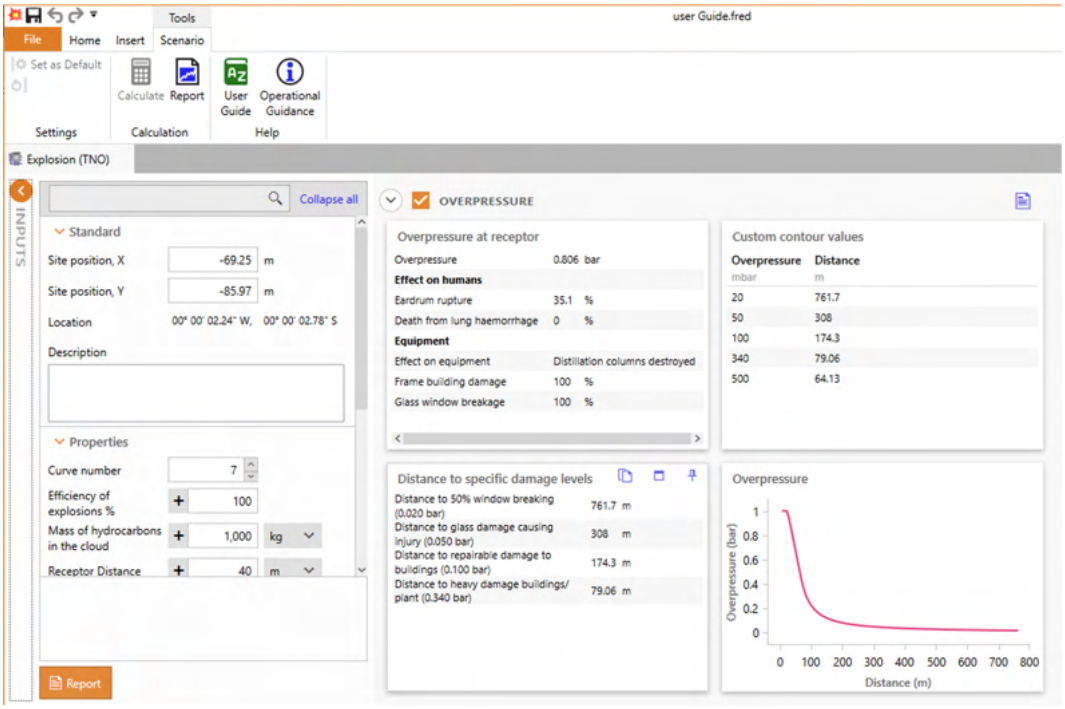
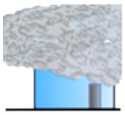


Figure 7: The inputs and results for the TNO Explosion model

3.4. Smoke



The smoke scenario models the ingress and build-up of smoke contaminants (Carbon monoxide and soot) inside a compartment, for example to design offshore temporary refuges and living quarters.

This smoke is produced from a fire source in the vicinity of the compartment which is modelled as part of running this scenario. The compartment could be an offshore temporary refuge/living quarter or an onshore shelter.
A time dependent carbon monoxide concentration is built up inside the compartment and is subsequently fed into a dynamic model that quantifies the physiological response to Carbon monoxide exposure, and hence calculates the time to impairment. Soot concentration is used to quantify the visibility using simple empirical correlations (see Figure 8).

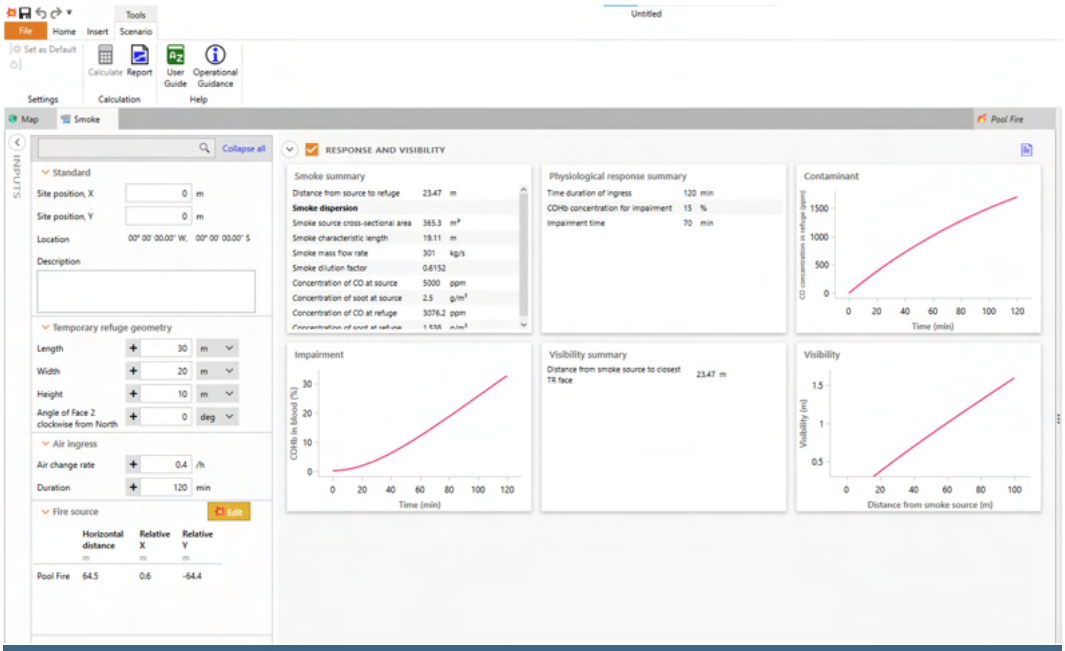


Figure 8: The inputs and results for the Smoke model

4. Changes to User Interface

This release includes some new UI functionality and a number of changes to the user interface to make it more intuitive.

4.1. Chart and Panel Displays

- Background images can now be imported into charts (see Figure 9). This functionality allows hazard information to be overlaid on an image, for instance a side views of jet fires from a flare. The functionality applies to all charts, except those with a logarithmic axis. The image can be repositioned and scaled to fit the release conditions of the hazard.

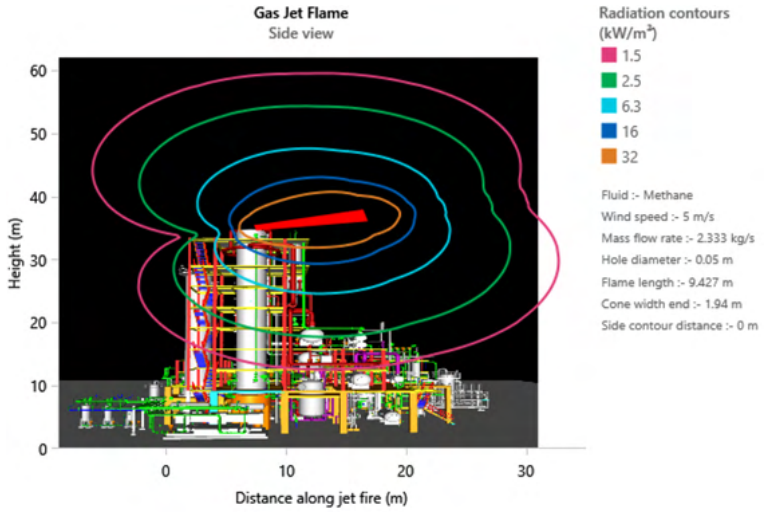
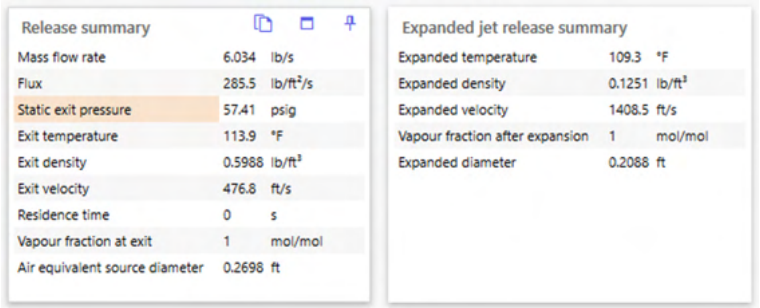


Figure 9: Side view with background image

- All results can now be displayed in internationalised units in all scenarios (see Figure 10). These units are set in File | Settings.



Release summary

Mass flow rate	6.034	lb/s
Flux	285.5	lb/ft²/s
Static exit pressure	57.41	psig
Exit temperature	113.9	°F
Exit density	0.5988	lb/ft³
Exit velocity	476.8	ft/s
Residence time	0	s
Vapour fraction at exit	1	mol/mol
Air equivalent source diameter	0.2698	ft

Expanded jet release summary

Expanded temperature	109.3	°F
Expanded density	0.1251	lb/ft³
Expanded velocity	1408.5	ft/s
Vapour fraction after expansion	1	mol/mol
Expanded diameter	0.2088	ft

Figure 10: Display of results in international units

- The selection of alternative units are now saved to the users profile and are available the next time Shell FRED is started.

- The min/max values for multiple charts on the dashboard can be updated at the same time (see Figure 11).



Figure 11: Resizing axis limits for multiple charts

- The selected component for dispersion calculations is now displayed on dispersion charts.
- The display of the legend has been adjusted to maximise the width of the chart.
- Improved labelling for x and y axis labels for side and top view charts.
- Improved formatting for the titles of both charts and table panels when showing variants.
- Generation of 3D output is now calculated asynchronously and does not freeze user input.

4.2. Tab controls and windows

- Improved usability of temporary / permanent tabs (see Figure 12). A scenario can be opened as a temporary tab by selecting its name in the Scenario Explorer and is now displayed on the right-hand side of the tab bar. This is shown in the Scenario Explorer via the vertical dotted line adjacent to the scenario name (red circle and arrow). When the scenario is double clicked or a temporary tab is promoted to a permanent tab, it is always shown on the left-hand side of the tab bar and the vertical bar is a solid line (yellow circle and arrow).

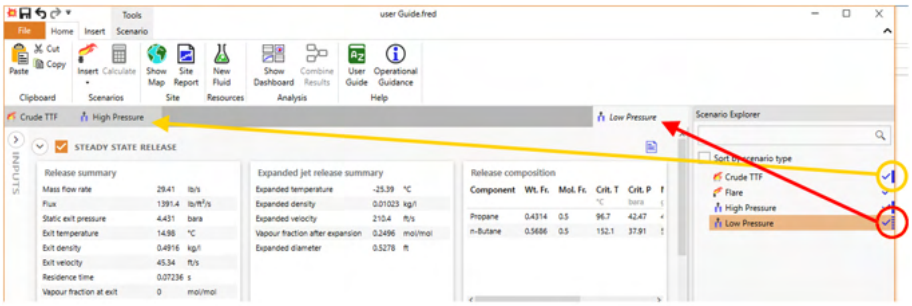


Figure 12: Display of temporary and permanent tabs

Functionality to move tabs to separate windows has been implemented (see Figure 13). All permanent tabs, including the map view, can be dragged to a separate window outside the FRED application framework. This feature makes it easier to see multiple views at the same time, for instance when moving receivers with respect to scenarios.

- Functionality to move tabs to separate windows has been implemented (see Figure 13). All permanent tabs, including the map view, can be dragged to a separate window outside the FRED application framework. This feature makes it easier to see multiple views at the same time, for instance when moving receivers with respect to scenarios.

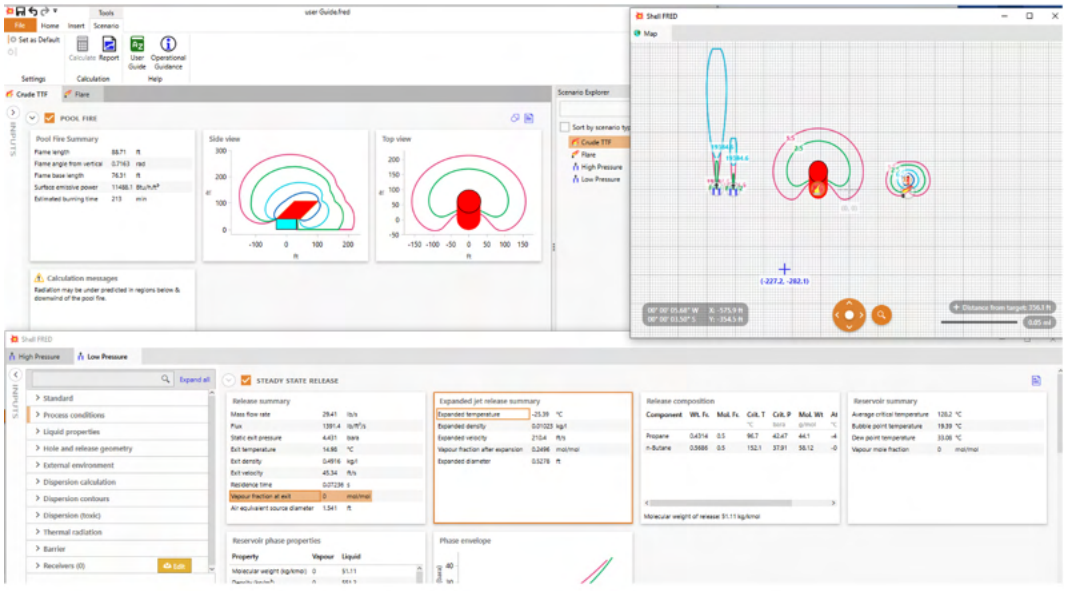


Figure 13: Moving permanent tabs to separate windows

- The panels can be rearranged on the dashboard to give a better layout for reporting. The updated view is stored in the FRED file and is used during report generation.

4.3. Scenario/Fluid Explorer

- Scenarios / fluids can now be filtered using search criteria (see Figure 14). FRED will use the filter criteria to show any scenarios or fluids that contain the text entered by the user within their titles, including the titles of any variants. This is updated dynamically as the user types.

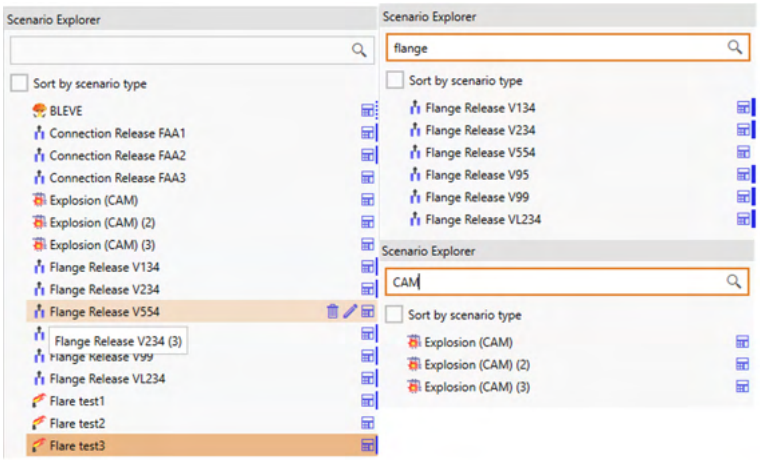


Figure 14: The search functionality in Scenario/Fluid Explorer windows

- The scenarios can be sorted by scenario type to help find specific scenario types using the checkbox at the top of the Scenario explorer window (see Figure 15).

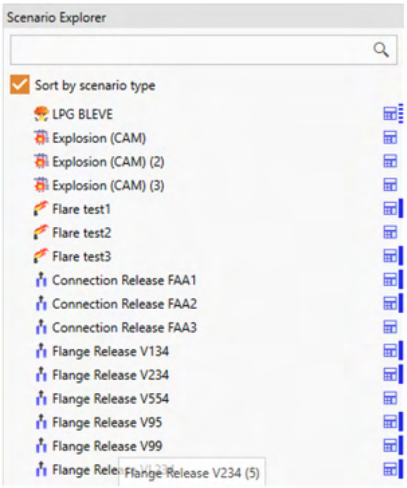


Figure 15: The Sort option in the Scenario Explorer window

- Right click functionality has been added to the Scenario Explorer (see Figure 16). User can right click a scenario in the Scenario explorer window to generate a popup menu. This menu enables users to cut, copy and paste.
  It also enables uses to show contours on the map view. The map view will be displayed if it is not the current active tab.

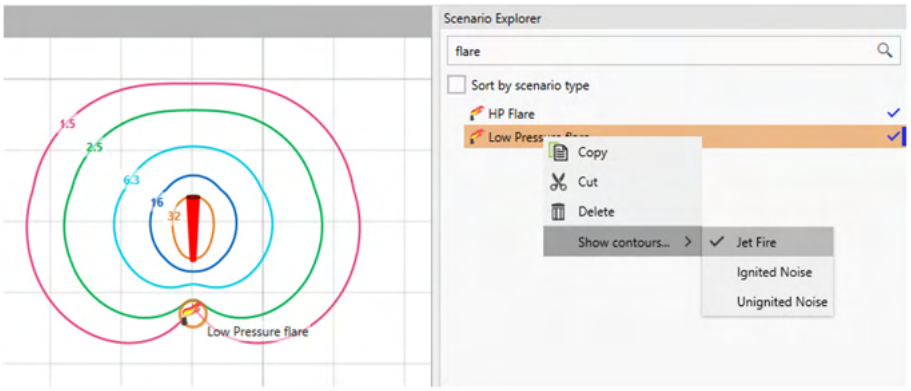


Figure 16: Right click functionality in Scenario Explorer window

4.4. Map View

- Scenario names can be toggled on/off in the map view (see Figure 17). This can be achieved either via the Overlays sub-menu or by right clicking a scenario on the map.



Figure 17: Functionality to display scenario names

- Functionality has been added to allow scenarios to be moved to an exact location by defining the coordinates within the map view using the right click menu (see Figure 18).

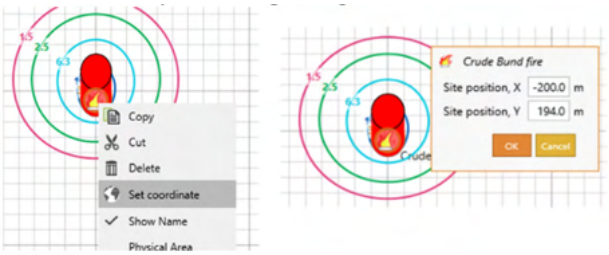


Figure 18: Functionality to position scenarios accurately

- The scale bar and coordinates on map can be hidden if required for output in reports.
- The display of contours from scenarios with variants has been improved (see Figure 19). Selecting the master scenario will display contours all variants for a specific value, e.g. 1.5 or 6.3 kW/m2. The contour value can be selected from the "variant" option on the Overlay menu. All contour values for a given variant can also be displayed by selecting that variant in the Scenario Explorer view.

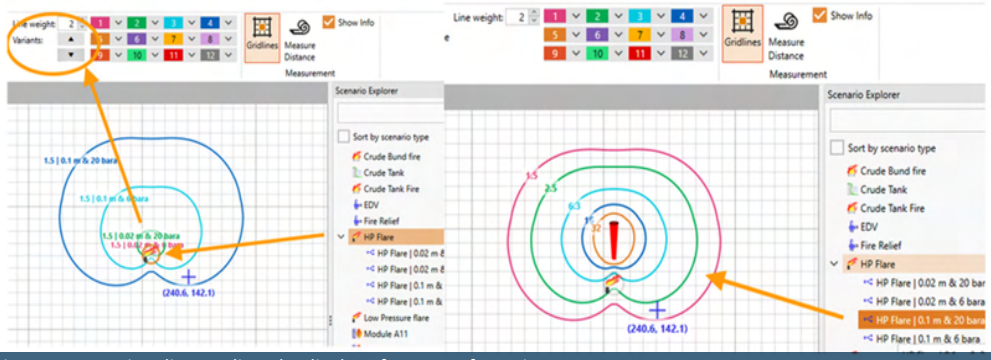


Figure 19: Functionality to adjust the display of contours for variants

- Fatality and dose top view plots (Pressurised Release – finite duration dispersion model) can now be displayed on the map.

4.5. Variants

- Improved handling of variants (capacity and speed) and reduced issues causing crashes.
- Improved generation of variant inputs (see Figure 20). An automatically calculated variant is calculated by default each time the '+' icon is pressed. For the first variant, this is based upon the last decimal value, whereas for subsequent variants it is the difference between the previous two variants

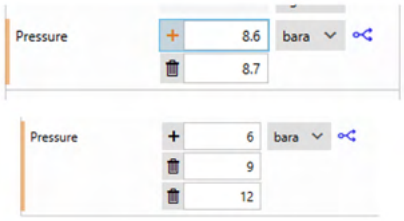


Figure 20: The functionality to add new variants

- Units are now added to variant names (see Figure 21).



Figure 21: The updated names of variants

- Renaming of variants is now allowed.
- Stability class is now displayed as the shortened text A, B, C etc in a variant name.
- Additional contours in Dense Gas Scenario are no longer created as variants and are simply created as additional plots on the plan view chart (using the same process as Pressurised Release scenario dispersion).
- Improved user interface to make it clearer that receivers cannot be defined when using variants.
- Scenarios with variants are now loaded in a collapsed state to reduce the info shown initially.

- Increased flexibility to pin parent or individual variants to dashboard (see Figure 22). A double pin option has been added to chart panels when showing a scenario that contains variants. Pressing the double pin locks the charts for all the variants to the dashboard (circled in red) to allow the information from variants to be compared side-by-side in the dashboards. The single pin shows the master scenario with the variants plotted on the single chart.

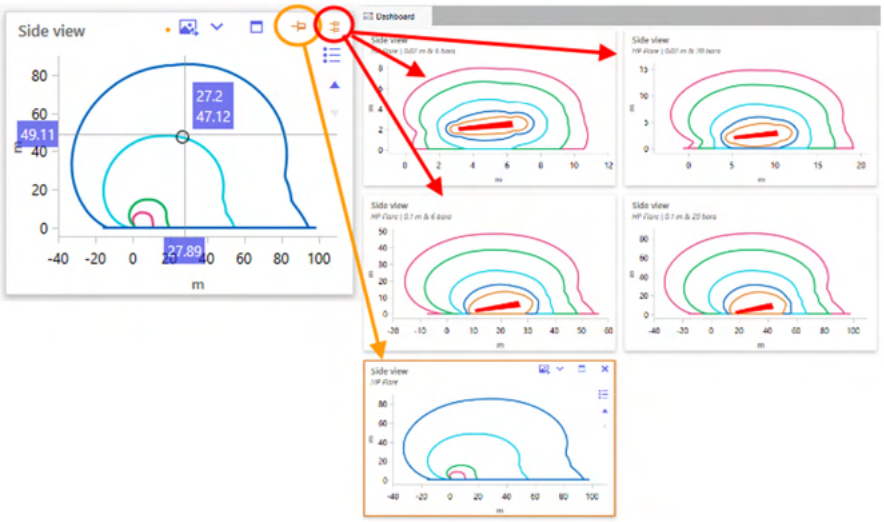


Figure 22: Functionality to pin a master or individual variants and the resultant display in the dashboard

4.6. Custom Fluids

- The architecture of custom fluids has been improved (see Figure 23). By default all custom fluids will now be stored on the user's PC (local fluids). This means that they will be available for all new projects. In addition, when a user saves a FRED scenario it will only include details of the fluids that have been used within a scenario. This means that you want to include a custom fluid in a FRED file for future reference, then you need to use it in a scenario OR export the fluid (see import/export enhancement).

  Fluids that are loaded from a .fred file are indicated by an ⓘ symbol to indicate project only (unless they are also present on your PC). A project fluid can be made into a local fluid by pressing the + icon in the fluid explorer window.

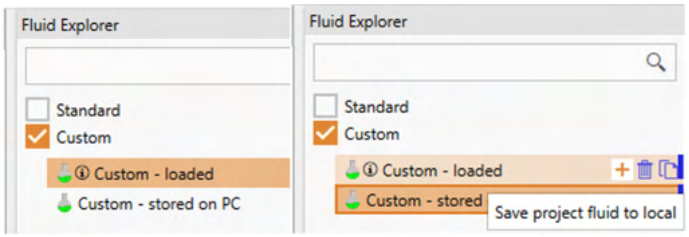


Figure 23: The display of project fuels in the Fuel Explorer window

- Custom fluids can now be exported/imported to Excel (see Figure 24). This functionality can be used; to store custom fluids for future project reference, to send to another user, or to create custom fluids externally and batch import. The functionality can be accessed via the fluid section of the insert menu.

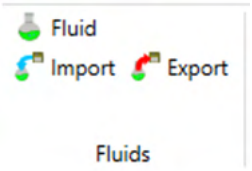


Figure 24: The options to import/export custom fluids.

- Extra information can be displayed in the Fluid selection input box (see Figure 25). This is either the CAS ID for individual components or an indication that the fluid is a standard mix or a custom fluid.
  This additional information can be used to improve the searchability of fluids.

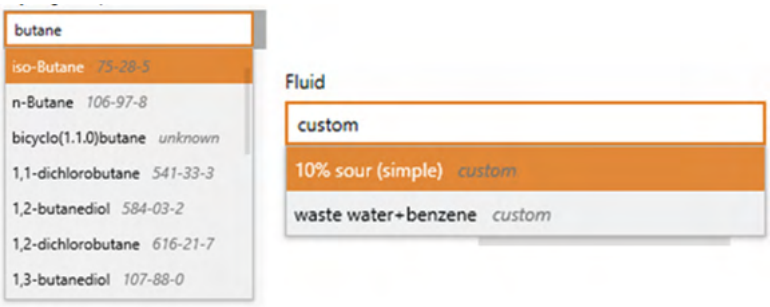


Figure 25: The interface to display and search by CAS IDs

- The deletion of custom fluids has been added to possible undo actions.

4.7. General Improvements

- Functionality to generate and attach .fred file to an email has been added.
  (This requires Outlook to be setup as the default email client).
- The input groups are highlighted if input fields contain validation errors (see Figure 26).



Figure 26: The warning icon when input groups contain validation errors

- Calculated "inputs", for instance volume in CAM, are now indicated in reports.
- The format of the title page of reports has been improved.
- A contents page has been added to site reports.
- The export fuel to Shepherd option in the Pressurised Release has been modified so that it can be used in Shepherd ellipse scenarios when the next version of Shepherd is released in 2022.

5. Bug Fixes

5.1. User Interface

- Fix stability issues when variants are constructed. This was causing FRED to crash when selecting the variant after reloading the .fred file.
- Fix issue where the calculation icon was sometimes missing in Scenario Explorer when loading scenarios with variants.
- Circular pool fire contours on the map are now cleared when the sub-model is switched to a Trench Fire sub-model.
- Panels on the dashboard are now shown as no longer valid (results out of sync) if the inputs for the corresponding scenario have changed and the scenario needs to be recalculated.
- Input values are now stored correctly when a ',' is defined as the decimal separator.
- All receiver results are now displayed when scenarios with multiple receivers are reported.
- Improved input validation for pipe length / pipe diameter in Pressurised Release scenario.
- Fix issue where fluid is not compatible for specific scenario after fluid is copied.
- Ensure that the chart format menu is not available when the currently selected panel is not a chart.
- Fix issue in custom fluid editor that caused the fluid to be removed from all Scenarios where it had been selected.
- Setting the elevation of a pool fire to be > 0 no longer causes a crash when exporting a 3D pool file.
- Fix crash when a calculating dispersion in a scenario, when its name contained the % character.
- Fix issue when dispersion calculations returned error when there were space (' ') characters at end of the scenario name.
- Chart axis titles are now centred when charted is copied.
- FRED will no longer crash if loading a .fr7 file that contains more than 10 plume travel times.
- Fix issue in Gas Jet scenario when the modified flag on pressure is shown for default scenario.
- Correct links to operational guidance for Temperature Rise scenario.
- Corrected reports to remove the repeated information about scenario position.
- Improve error handling when loading some Jpeg files onto the map.
- Correct unit for rise time in sub-sea model from m to s.
- Fix crash when setting Negligible Retreating Speed in Receiver objects.
- Correct the axis labels for pressure decay chart in Vessel Burst scenario, which were swapped.
- Reimplement calculation message if gas release does not have discharge coefficient of 0.8 and liquid release does not have discharge coefficient of 0.6.

5.2. Science

- Fix issue in Jet Dispersion results, which were truncated at a shorter distance if the water content is too high and the molecular weight without water is also high.
- Ensure that the calculation message "calculated mass flow and requested mass flow rates differ by more than 1%" is shown for some release configurations.
- Correct the calculation of the boiling/evaporation flag in the transient pool model within Unified Scenario.

- Fix transient pool model in some cases to return calculation warning rather than error when the pool boils dry.
- Corrected the reported vapour density in 2-Phase Blowdown scenario when modelling full-bore release. The calculated flow rate / exit velocity was always correct.
- Correct display of Dew/bubble points in reservoir summary to show "n/a" when a non-physical solution is calculated instead of -300°C.
- Fix issues in finite duration centreline concentration plot when the initial concentration was not displayed correctly.
- Fixed starting condition in transient pool model when the fluid boiling temperature was incorrectly calculated when the fluid composition was defined by weight. The main impact was an error that the transient pool model could not start for a small range of temperatures.
- Improve contouring of plan view contours in Trench fire scenario. In some very specific cases the Trench fire plan view showed some spikes as the view factor calculations returned 0 rather than the correct distance.
- Fix implementation of insulated cold face (in FRED 7.1 and 2020) when Temperature Rise was set to model a wall. The "free convection in air" was always selected internally.

6. Backwards compatibility

Shell FRED 2022 will load files created using FRED 7 or FRED 2020.

If files are saved in older versions of FRED, these can be loaded into FRED 7.1 and saved as .fr7 files to make them compatible with FRED 2022.

Bibliographic information

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FRED

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Gexcon is a world-leading company in the field of safety and risk management and advanced dispersion, explosion and fire modelling. Our experience arises from detailed knowledge of explosion phenomena built up throughout years of conducting extensive research projects, carrying out safety assessments, performing accident investigations, and performing physical testing at the company's facilities.

About Shell

An international energy company that aims to meet the world's growing need for more and cleaner energy solutions in ways that are economically, environmentally and socially responsible.

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