Argos User's Guide

A step by step guide to fire simulation

By Thomas Deibjerg, Bjarne Paulsen Husted, Henrik Bygbjerg and David Westerman

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Danish Institute of Fire and Security Technology (DIFT)

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Trademarks

Illustrations:

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Introduction

Welcome to Argos

Argos is a software-based zone model used for simulating fire development and smoke transport in an enclosure. Argos can be used by engineering companies, regulators, fire brigades, and insurance companies to assess fire hazards.

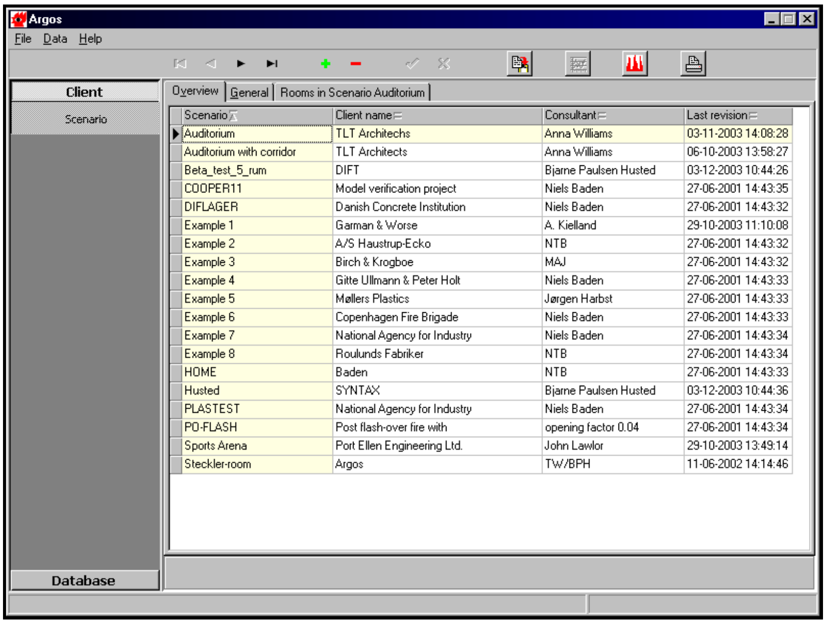


Figure 1. The Argos main window.

Using Argos you may calculate and predict the effect of a specified fire on temperatures, gas concentrations, and smoke layer heights in multi-compartment buildings. Argos models up to 5 compartments in one scenario.

The output from Argos is presented in various graphs.

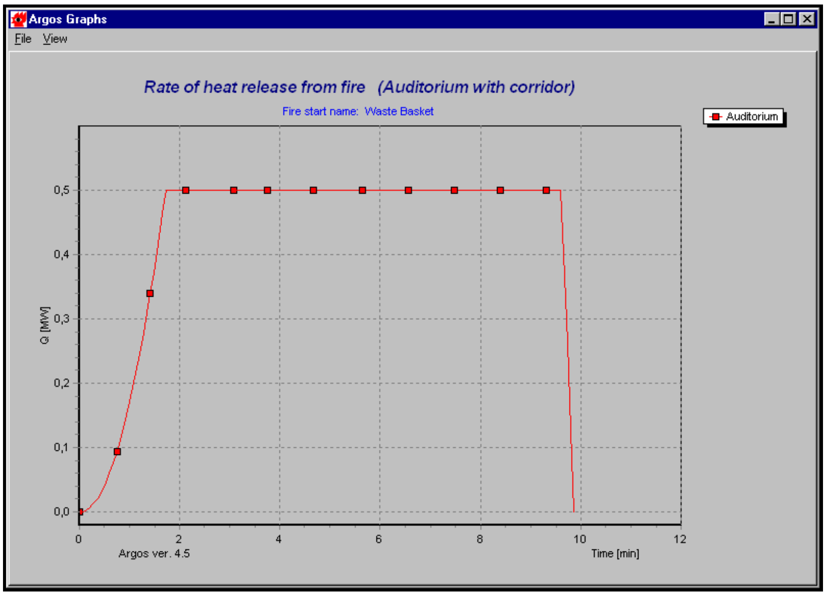


Figure 2: Graph depicting the rate of heat release from a fire.

About this User’s Guide

The Argos User’s Guide is structured as follows:

- *Chapter 1: Getting Started with Argos* – provides a general introduction to the program and its graphical user interface.
- *Chapter 2: Concepts of Fire Simulation* – presents the purposes and concepts of fire simulation such as zone modelling, fire growth, fire types, etc.
- *Chapter 3: Fire Simulation in Argos* – describes the process of setting up and running fire simulations in Argos. The chapter

provides a detailed presentation of how to enter data into Argos and interpret the simulation results.

- *Chapter 4: Case Scenarios* – presents a series of case scenarios to provide inspiration for your own use of Argos.
- *Chapter 5: Graphs in Argos* – describes the output graphs of Argos; what they show; and how they may be used in the analysis.
- *Chapter 6: Presenting Your Work* – provides useful information about how to present the simulation report, for instance when seeking approval of the building by the authorities.
- *Chapter 7: Working in the Argos Database* – presents the structure of the Argos database and describes how to create new entries such as initial fires.
- *Chapter 8: Backing Up Your Work* – describes how to back up scenarios and the Argos database.
- *Glossary* – a terminology list of the most commonly used terms in fire simulation and in Argos.

Additional information on Argos

For additional information on Argos, please refer to the following sources:

- *The Argos Help* – You access the help system by pressing F1 anywhere in the program. The Argos Help is context sensitive, which means that you will get help for the current screen or dialog box.
- *The Argos Theory Manual* – The theory manual describes the technical and mathematical background of Argos. The manual comes as a PDF document accessible from the Argos application group in the Documentation folder. (See figure next page).

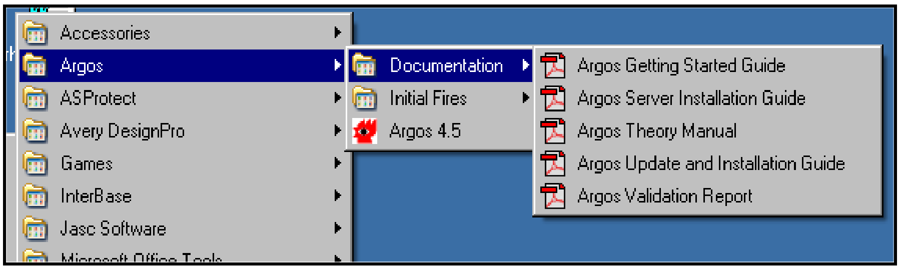


Figure 3: PDF documentation of Argos

- *The Argos Update and Installation Guide* – This guide describes how to install the program and attach the dongle to the computer. The document is sent to you when you purchase the program. It is also available as a PDF document in the Argos application group in the Documentation folder.
- *Argos Server Installation Guide* – The Argos Server Installation Guide describes how multiple users can use the same database. This is only relevant if there are multiple users of the program on the same site or across a network. The document comes as a PDF document accessible from the Argos application group in the Documentation folder.
- *The Argos Getting Started Guide* – The Argos Getting Started Guide is a quick-start guide based on relevant screen shots. It is also available as a PDF document, accessible from the Argos application group in the Documentation folder.
- *The Argos Validation Report* – The Argos Validation Report is a verification of Argos against 3 different experiments. Currently this is validated for the DOS version of Argos, but since the Windows version has been verified against the DOS version, the results are also valid for the Windows version of Argos. The manual comes as a PDF document accessible from the Argos application group in the Documentation folder.
- *The Initial Fires report by Stefan Särdqvist* – The Initial Fires report is included in Argos with the kind permission of Stefan

Särdqvist and The Department of Fire Safety Engineering at Lund University. The report contains data from a total of 199 experiments, ranging from Christmas trees to cars. These fire data are included in Argos and the report includes additional information about the different fires, how they were tested etc. Furthermore, it gives a good overview of all available fires. The individual fire codes in the report are the same as those used in the program. The report comes as a PDF document accessible from the Argos application group in the Initial Fires folder.

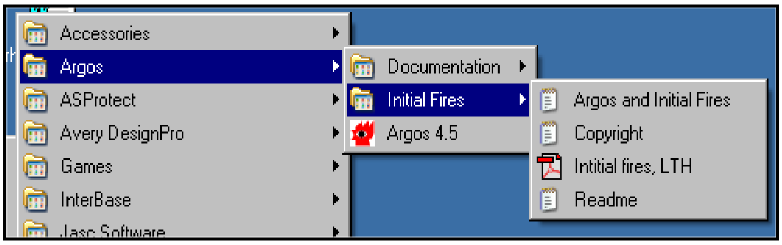


Figure 4: Initial fires documentation

Simulating a Fire — The Basic Stages

The process of simulating a fire is thoroughly described in *Chapter 3: Fire Simulation in Argos* and exemplified in *Chapter 4: Case Scenarios*. Initially, here is a brief overview.

Simulating a fire in Argos comprises the following stages:

- Specifying requirements based on the usage of the building
- Setting up the scenario (entering basic construction data)
- Running the scenario (making calculations)
- Viewing and interpreting the results (comparing the requirements with the calculated results).
- Customizing and re-running the scenario to get comparison results.

Specifying Requirements

As a first step, you need to draw up the overall requirements of the building. Where is the building to be located; what is it to be used for; what is the basic building construction (wood, concrete); how many rooms will it hold; what are the surroundings, etc.

Before entering data into Argos, there are several things to consider in order to create the best possible scenario: What fires are likely to occur and what fire installations should be tested? Do the walls have any openings? Do they connect to other rooms? What are their geometry and location? Will any doors be opened/closed after a period of time?

Setting Up the Scenario

When *setting up the scenario* in Argos, you enter the various types of data into Argos. These data may include (not all information is mandatory):

- Basic scenario information such as scenario name, company type and construction information.
- The number of rooms and the basic geometry of each room — area and height.
- Information about doors, the walls connecting the rooms, and the surroundings (materials used and wall lengths).
- Information about the ceiling and any openings in the ceiling (materials used and geometry).

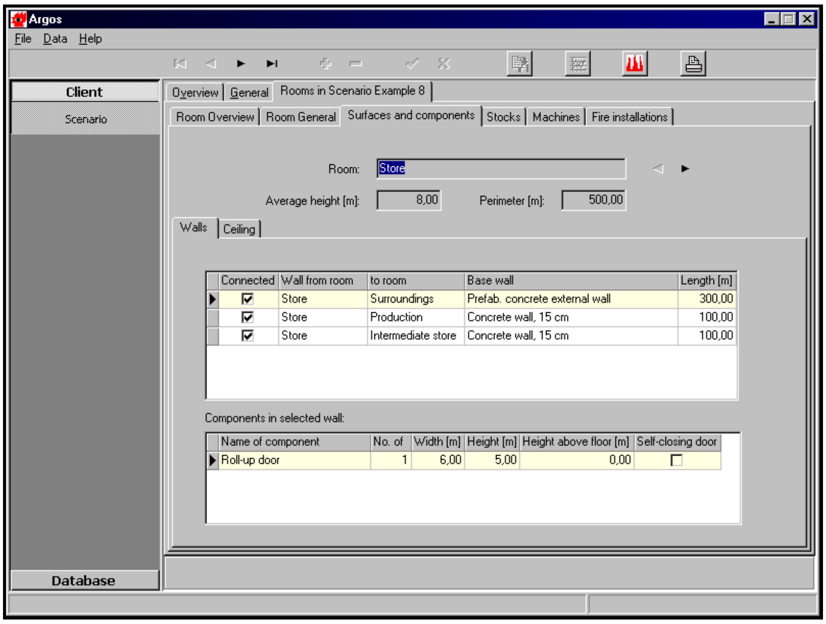


Figure 5: Surface and component details of a wall in an Argos case scenario.

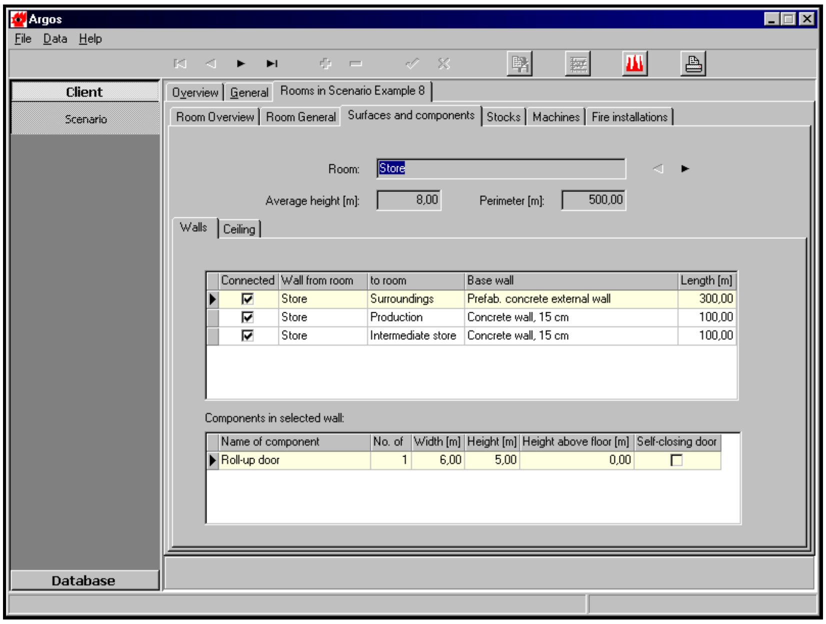


Figure 6: Argos allows you to print a report of the current client file.

Running the Scenario

When *running the scenario* in Argos, you choose an initial fire and let Argos calculate how temperatures and smoke develop within the enclosure.

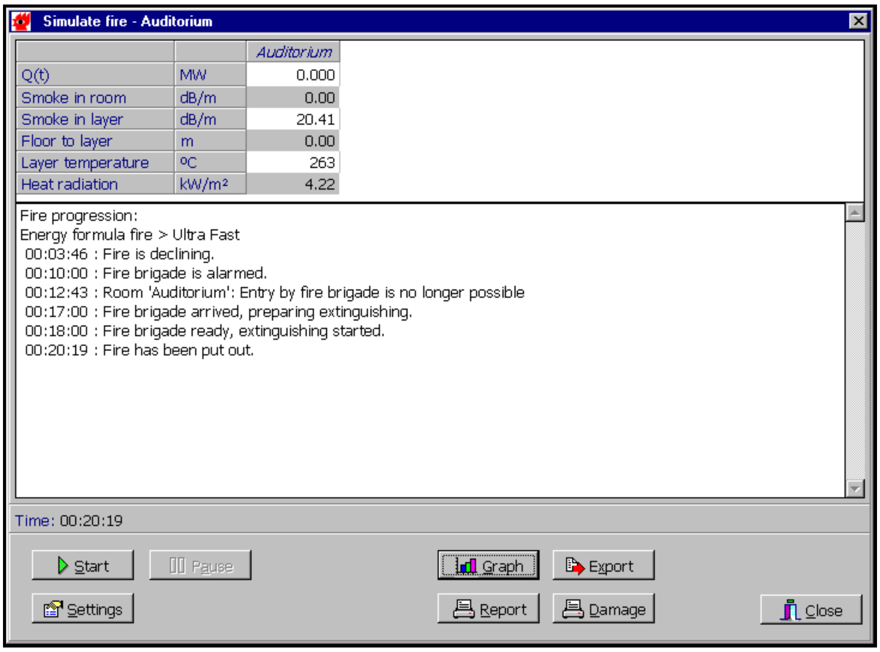


Figure 7: The Simulate fire window.

Once you have run a simulation, you may go back, change the input data and launch a new simulation for the current scenario. For instance, you can see how the simulation changes if you install another fire installation or choose to install self-closing doors

The output from Argos is presented in graphs. Among other things, they will show:

- the rate of heat release from the fire
- smoke density in rooms and in smoke layers
- thickness and temperature of the smoke layer

- heat radiation from smoke layers
- heat loss through surfaces
- ceiling temperature profile

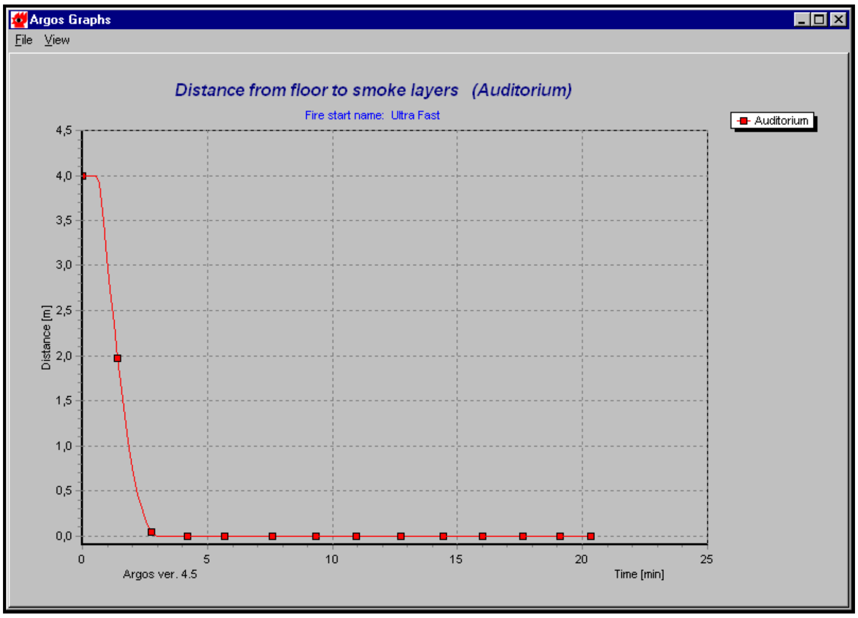
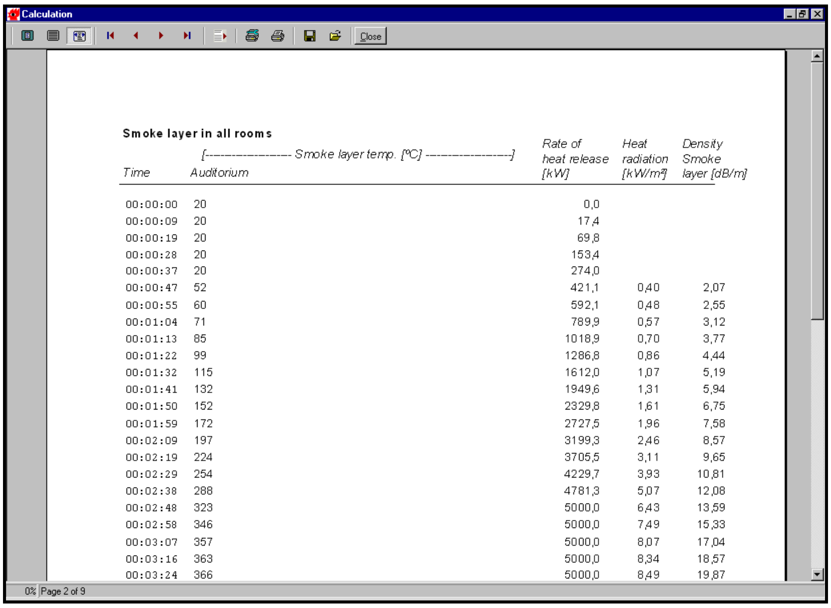


Figure 8: Graph depicting the distance from floor to smoke layers.

For further information about the graphs in Argos, turn to Chapter 5: Graphs in Argos.

In addition to the graphs, Argos allows you to print a detailed calculation report.



Smoke layer in all rooms

Time	[------ Smoke layer temp. [ºC] ------] Auditorium	Rate of heat release [kW]	Heat radiation [kW/m²]	Density Smoke layer [dB/m]
00:00:00	20	0,0		
00:00:09	20	17,4		
00:00:19	20	69,8		
00:00:28	20	153,4		
00:00:37	20	274,0		
00:00:47	52	421,1	0,40	2,07
00:00:55	60	592,1	0,48	2,55
00:01:04	71	789,9	0,57	3,12
00:01:13	85	1018,9	0,70	3,77
00:01:22	99	1286,8	0,86	4,44
00:01:32	115	1612,0	1,07	5,19
00:01:41	132	1949,6	1,31	5,94
00:01:50	152	2329,8	1,61	6,75
00:01:59	172	2727,5	1,96	7,58
00:02:09	197	3199,3	2,46	8,57
00:02:19	224	3705,5	3,11	9,65
00:02:29	254	4229,7	3,93	10,81
00:02:38	288	4781,3	5,07	12,08
00:02:48	323	5000,0	6,43	13,59
00:02:58	346	5000,0	7,49	15,33
00:03:07	357	5000,0	8,07	17,04
00:03:16	363	5000,0	8,34	18,57
00:03:24	366	5000,0	8,49	19,87

Figure 9: A fire calculation report.

Chapter 1: Getting Started with Argos

This chapter describes how to get started with Argos. The interface is introduced and the overall principle for simulating fires in the program is presented.

Launching Argos

To launch Argos, double-click the Argos shortcut on the desktop. Alternatively, select **Start**, **Applications**, **Argos 4.5**. The Argos main window opens:

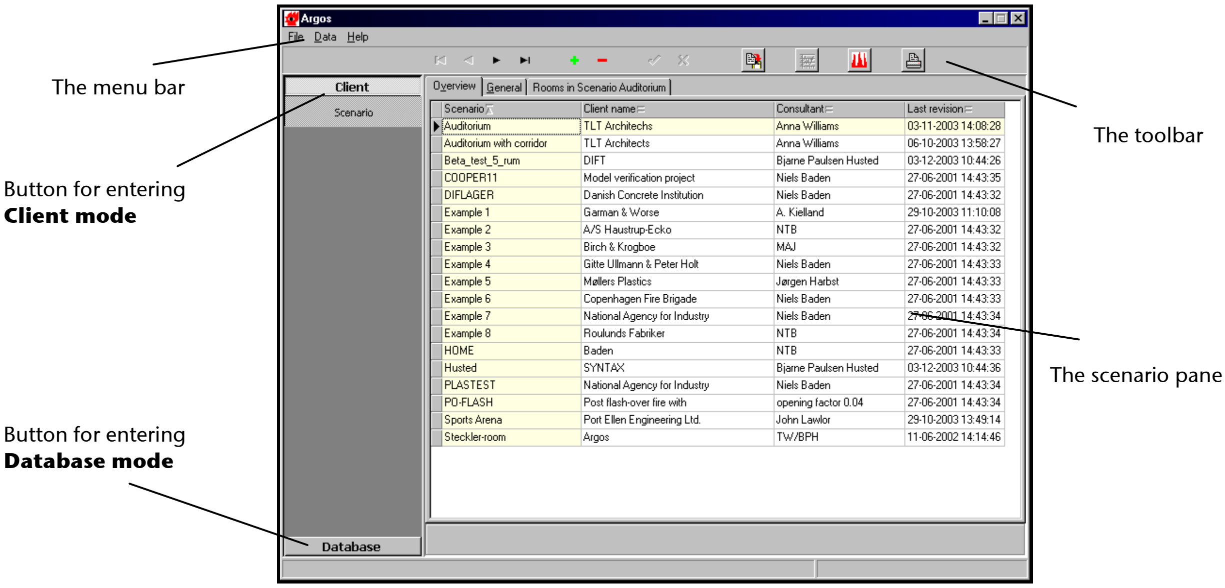


Figure 1.1: The Argos main window.

The Argos Main Window

The main window is where you set up your scenarios and toggle between Client mode and Database mode.

The window contains a menu bar, a toolbar, a scenario pane and the left-hand panel, which lets you toggle between *client mode* (where you set up your scenarios) and *database mode* (which provides access to configuring data records in the Argos database).

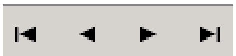
The Menu Bar

The menu bar provides access to various user commands in both Database and Client mode. Most commands are also available from the toolbar and hence described in the following section, *The Toolbar*.

For a dedicated description of the **Parameters** command, turn to the section *The Parameters command* later in this chapter.

The Toolbar

The toolbar is available in both Database and Client mode.



Navigation buttons used for navigating between the different scenarios or database records.

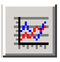
The **Create** button. Creates a new scenario or a database record. By default, a new record is labelled *Unknown* until you provide a name for it on the **General** tab.

The **Delete** button. Deletes the selected scenario or database record.

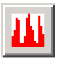
The **Save changes** button. This button is only active when editing or creating scenarios and database records. Clicking the button will save the recent changes.

The **Cancel changes** button. This button is only active when editing or creating scenarios and database records. Clicking the button will cancel the recent changes.

The **Copy fire or scenario** button. When in Client mode, this button will copy the currently selected scenario to a new scenario. When in Database mode, the button will copy the currently selected fire. Only fires can be copied in Database mode.



The **Show fire graphs** button. Shows the graphs generated for the current fire. The button is only available for the currently selected fire in Database mode.

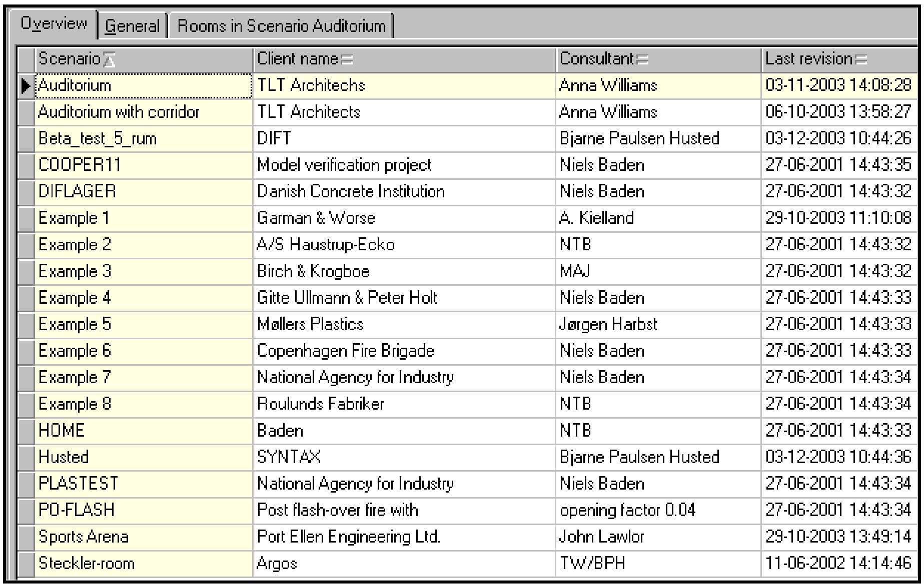


The **Simulate fire** button. Click this button when you are ready to simulate the fire development in your scenario. The button will open a separate window in which you launch the fire.

The **Print** button. Prints the information related to the selected scenario or database record.

The Scenario Pane

This is where all scenarios appear. Note that Argos comes with a set of predefined scenarios, which you may run for test purposes and to get acquainted with the program.



Overview | General | Rooms in Scenario Auditorium

Scenario	Client name	Consultant	Last revision
Auditorium	TLT Architechs	Anna Williams	03-11-2003 14:08:28
Auditorium with corridor	TLT Architects	Anna Williams	06-10-2003 13:58:27
Beta_test_5_rum	DIFT	Bjarne Paulsen Husted	03-12-2003 10:44:26
COOPER11	Model verification project	Niels Baden	27-06-2001 14:43:35
DIFLAGER	Danish Concrete Institution	Niels Baden	27-06-2001 14:43:32
Example 1	Garman & Worse	A. Kielland	29-10-2003 11:10:08
Example 2	A/S Haustrup-Ecko	NTB	27-06-2001 14:43:32
Example 3	Birch & Krogboe	MAJ	27-06-2001 14:43:32
Example 4	Gitte Ullmann & Peter Holt	Niels Baden	27-06-2001 14:43:33
Example 5	Møllers Plastics	Jørgen Harbst	27-06-2001 14:43:33
Example 6	Copenhagen Fire Brigade	Niels Baden	27-06-2001 14:43:33
Example 7	National Agency for Industry	Niels Baden	27-06-2001 14:43:34
Example 8	Roulunds Fabriker	NTB	27-06-2001 14:43:34
HOME	Baden	NTB	27-06-2001 14:43:33
Husted	SYNTAX	Bjarne Paulsen Husted	03-12-2003 10:44:36
PLASTEST	National Agency for Industry	Niels Baden	27-06-2001 14:43:34
PO-FLASH	Post flash-over fire with	opening factor 0.04	27-06-2001 14:43:34
Sports Arena	Port Ellen Engineering Ltd.	John Lawlor	29-10-2003 13:49:14
Steckler-room	Argos	TW/BPH	11-06-2002 14:14:46

Figure 1.2: The scenario pane.

The scenario pane has three tabs: **Overview**, **General**, and **Rooms in Scenario**.

On the **Overview** tab, each scenario is represented by four columns: Scenario, Client name, Consultant, and Last revision. By clicking the column header you may sort the scenarios in descending or ascending order.

Client Mode and Database Mode

Argos may be run in two different modes, *Client mode* and *database mode*.

Client mode

Client mode is where you work with your scenarios. This is where you create and edit the scenarios and run the actual simulation and subsequently view and interpret the results.

To enter client mode, click **Client** in the Argos panel.

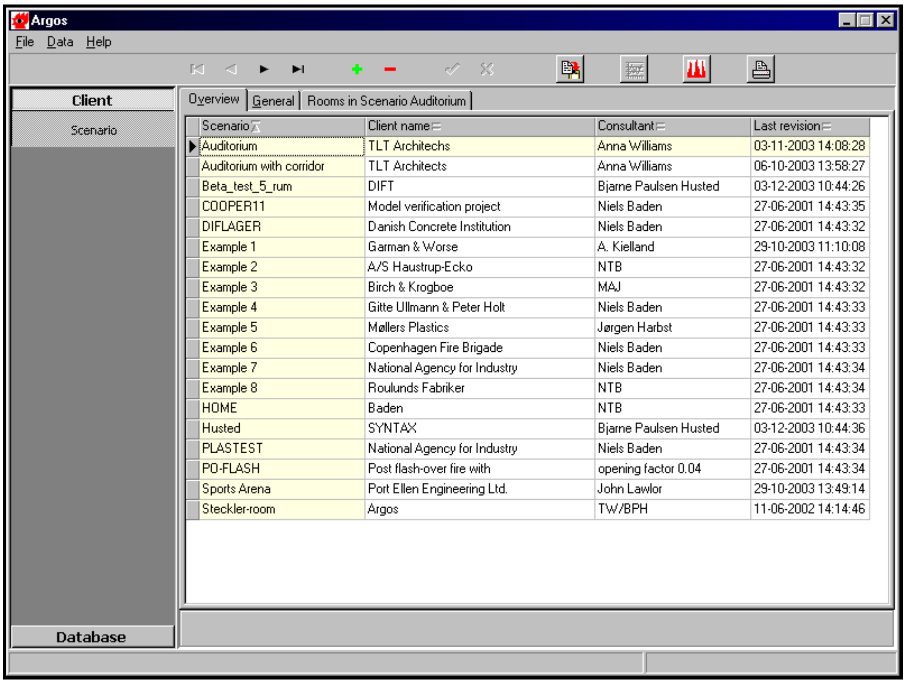


Figure 1.3: List of scenarios in Client mode.

Database mode

To enter database mode, click **Database** in the Argos panel. Database mode is where you create and maintain the data that are available in client mode: initial fires, heat detectors, building components, machines, room purposes, etc.

Argos comes with a large number of predefined records describing initial fires, stocks, machines, fire installations, and building components. If required, you may create your own records in Database mode. Turn to *Chapter 7: Working with the Argos Database* for more information on Database mode. The Argos database is also extensively documented in the Database section in the Argos Help.

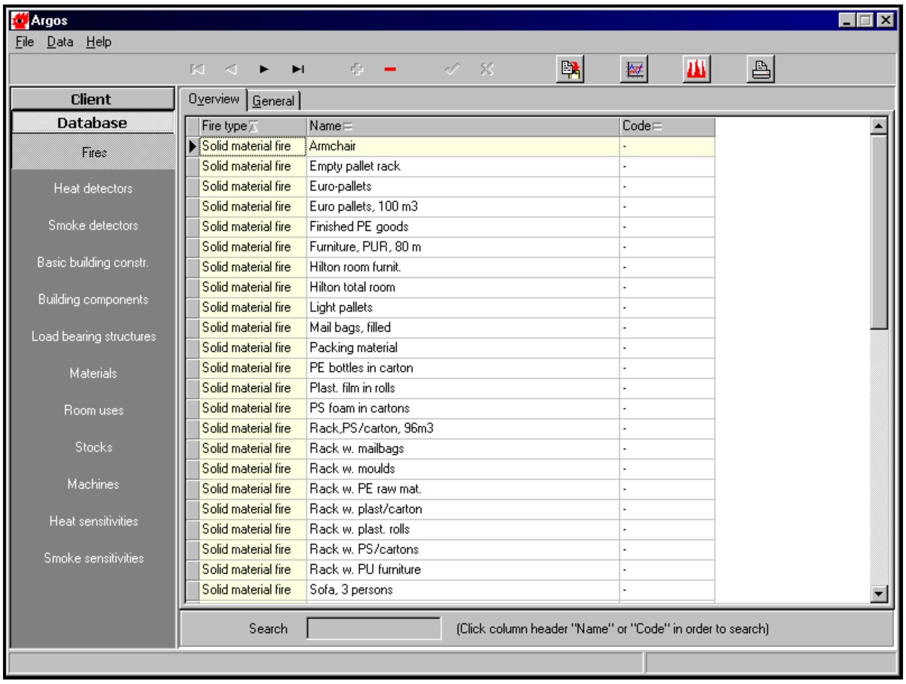


Figure 1.4: List of fires in Database mode.

The Simulate Fire Window

The **Simulate fire** window is where you launch the actual simulation. You activate the window by clicking the **Simulate fire** button on the toolbar.

This window lets you study how the fire progresses in terms of smoke, temperature, and radiation development.

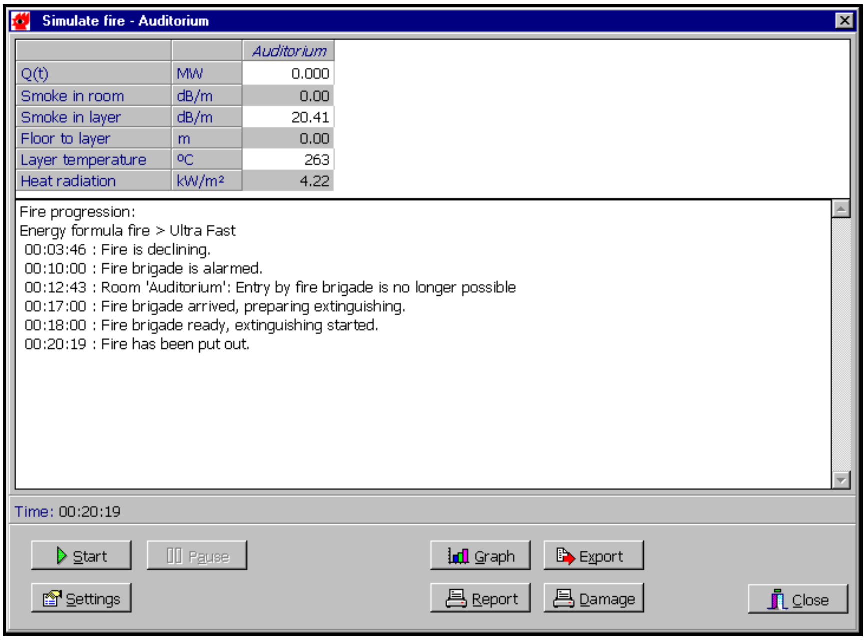


Figure 1.5: The Simulate fire window.

The Simulation Options Window

Prior to launching a simulation, you can set various simulation options, in order to adjust or change the circumstances for the fire simulation.

To open the **Simulation options** window, click **Settings** in the **Simulate fire** window.

For instance, you can run the same scenario with different initial fires and see how the results change. You can also adjust the time it will take for the fire brigade to arrive on the scene and turn fire installations on and off to see their impact on the results. Furthermore, you can choose to have doors open or closed during the simulation.

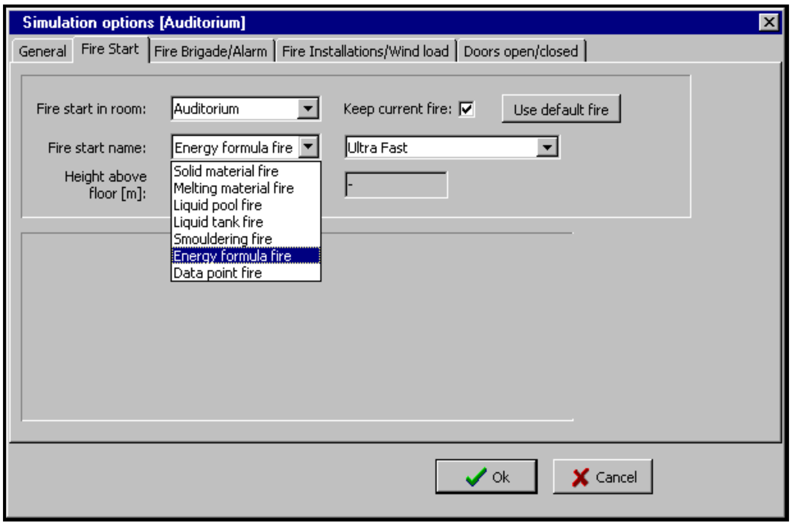


Figure 1.6: Selecting a fire in the Simulation options window.

The Parameters Command

For expert users only! The **Parameters** command in the **Data** menu deserves special attention, since the settings in the associated dialogue box influences how simulations are run in Argos.

The command opens the **Parameters** dialogue box, which contains a number of customisable parameters. Unless you are an expert user, we recommend that you do not change these parameters and instead use the factory settings. Unintended changes to these values will have a significant impact on the simulation results.

These parameters are common to all simulations, so remember to reset them to their original value if they have been changed for a specific calculation.

The parameters, which are most likely to be changed, are the two top parameters: *Fraction of rate of heat release radiated by the fire* and *Rate of heat release per area*, as these can be adapted to a specific fire.

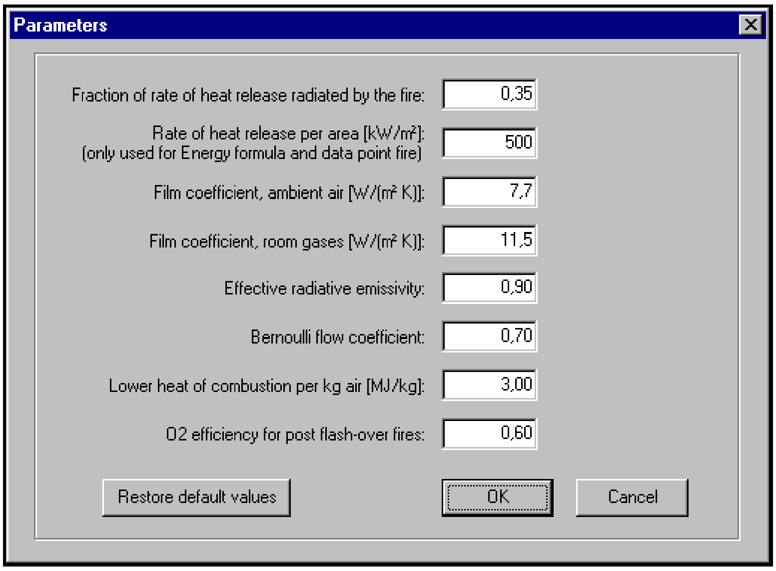


Figure 1.7: Use the Parameters dialog box to set various values that will control how simulations are run.

A fire that produces little smoke will have a lower radiation level (about 0.20), whereas a very sooty fire will have a higher radiation level (up to 0.5). Changing the rate of heat release per area will affect the flame height calculation as well as the safety distance from the fire when using energy formula and data point fires, as shown in Fire Area in chapter 7.

When doing performance based design without knowledge of the specific fire load, the rate of heat release per area can be used. For shops, malls etc., this could be set to 500 kW/m^2, which matches the average rate heat release per area in a building of this type. For other objects, such as tunnels, this value could increase significantly.

For further information about the **Parameters** command, see Argos Help.

Note!	If you alter the parameters by accident, click the **Restore default values** button to restore the factory settings.

Chapter 2: Concepts of Fire Simulation

Why Fire Simulation?

The reason we want to simulate fires is that it can provide us with the answers to a lot of vital questions regarding fire behaviour and smoke development prior to designing and constructing new buildings.

Smoke is the major hazard to life in a fire. 70 % of injuries and deaths in fires are due to smoke. It can also be the greatest threat to property. In some fires, 95 % of the losses have been due to smoke.

Running fire simulations with Argos allows you to get a detailed picture of the smoke conditions, such as smoke temperature, toxicity and visibility. The results you get from Argos will enable you to assess alternative smoke control strategies, evaluate life safety, and take the relevant passive or active fire precautions.

Zone Models

As mentioned earlier, Argos is a *zone model*. In zone models, the compartment is divided into several zones, which may include the fire or combustion zone; the plume; the compartment hot gas zone (the upper layer); the compartment ambient zone (the lower layer); and the outside ambient zone.

Argos is a 2-zone model in which the heated air is divided into an upper hot zone and a lower cold zone. More precisely, Argos starts out as a 1-zone model and then becomes a 2-zone model when the difference in temperature between the two layers is big enough.

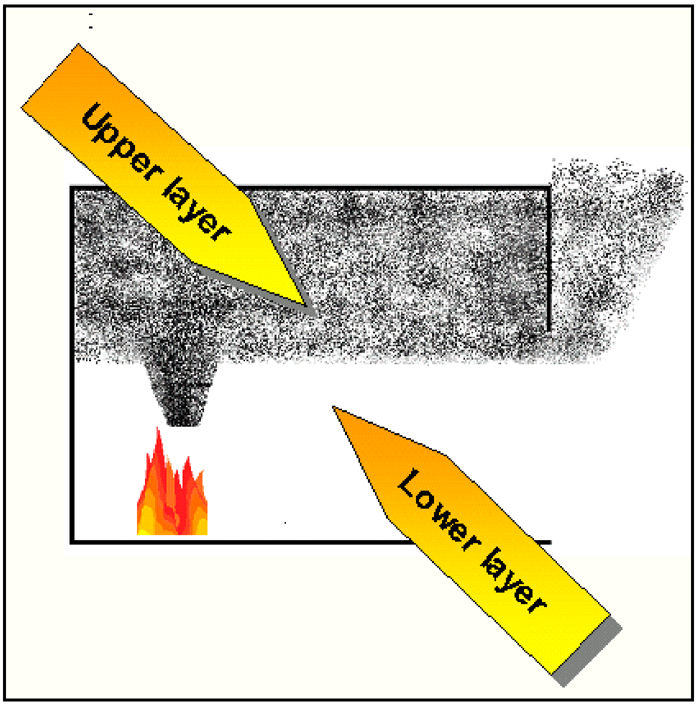


Figure 2.1: A 2-zone model.

Fire Life Cycle

There are four stages in the life of a fire:

- Ignition
- Fire growth period (pre-flash-over)
- Fully developed fire (post-flash-over)
- Decay — the fire is declining and dying out.

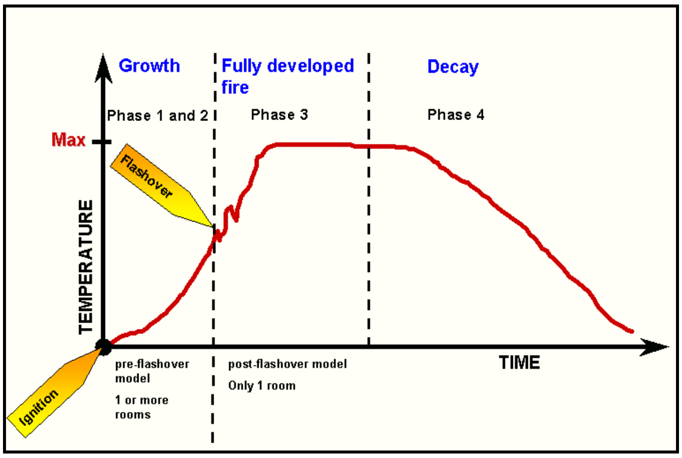


Figure 2.2: Fire life cycle (temperature versus time).

Given sufficient fuel and oxygen, the fire will continue to grow, causing an increase in compartment temperature. When substantial heat is generated (at 500-600ºC), flash-over occurs and the fire becomes fully developed, engulfing all combustible materials within the compartment. Decay follows when all the fuel or oxygen within the compartment has been fully consumed.

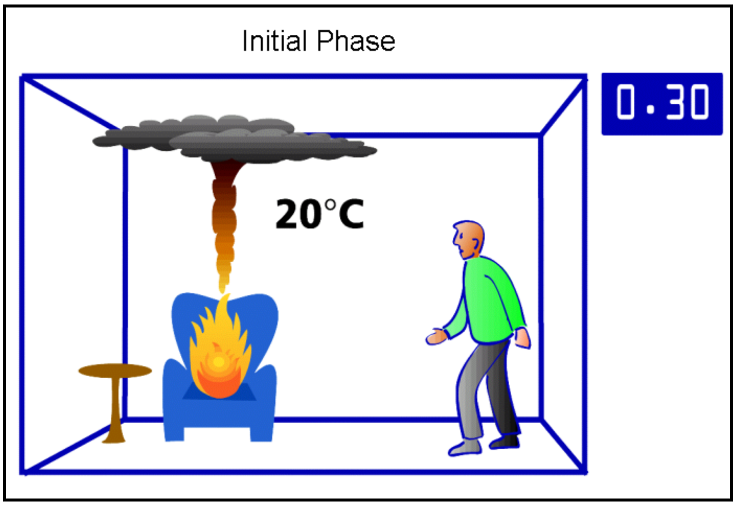


Figure 2.3: The initial phase of a fire.

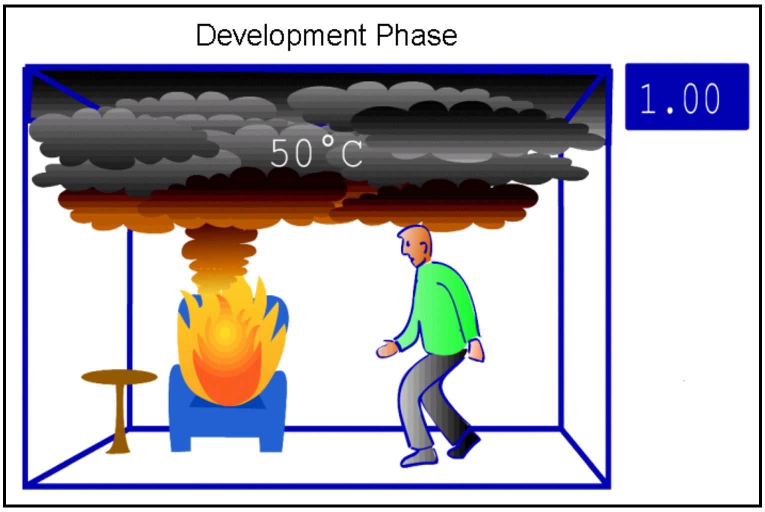


Figure 2.4: Developing fire – the smoke layer is generated.

Critical Conditions for Life Safety

Critical conditions occur if one or more of the following conditions are met.

- *Visibility*. If the visibility is less than 10 meters in a larger room or less than 3-5 m in smaller rooms, conditions are considered to be critical. A larger room is defined as a compartment larger than 150 m^2. A smaller room is defined as a compartment smaller than 150 m^2.
- *Distance from floor to smoke layer –smoke free height*. If this distance reaches a level which is less than 1.6 m + 10 % of the height of the room, conditions are considered to be critical. In a room with a height of 3 meters, the critical smoke height will be 1.90 m (1.6 + (0.1 x 3 m)).
- *Temperature in smoke free zone*. If the temperature in the smoke free zone reaches 60-80 °C, conditions are considered to be critical.

- *Heat radiation from smoke layers.* If the radiation surpasses is more than 2.5 kW/m^2, conditions are considered to be critical.
- *Oxygen level.* When the oxygen level is less than 15% in the lower layer, conditions are considered to be critical. At this point, it is no longer possible to breathe normally.
- *Carbon Dioxide (CO_2) level.* When the CO_2 level in the air is higher than 5%, conditions are considered to be critical.
- *Carbon Monoxide (CO) level.* When the CO level in the air is higher than 2000 ppm, conditions are considered to be critical.

The figures above serve as generally accepted criteria for critical conditions for life safety. Slight variations may exist between different countries (different regulations). We advise you to consult the appropriate documentation for your region.

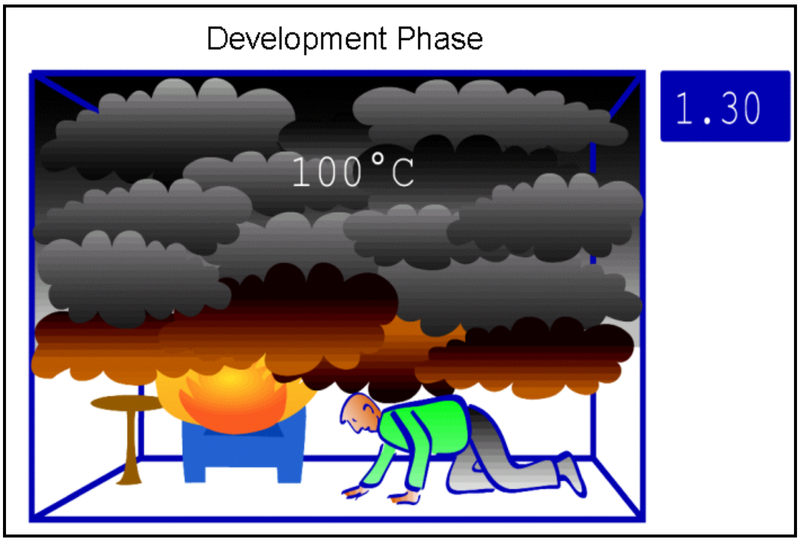


Figure 2.5: Fire still in development phase. Critical conditions have occurred within the room, i.e. distance from floor to smoke layer.

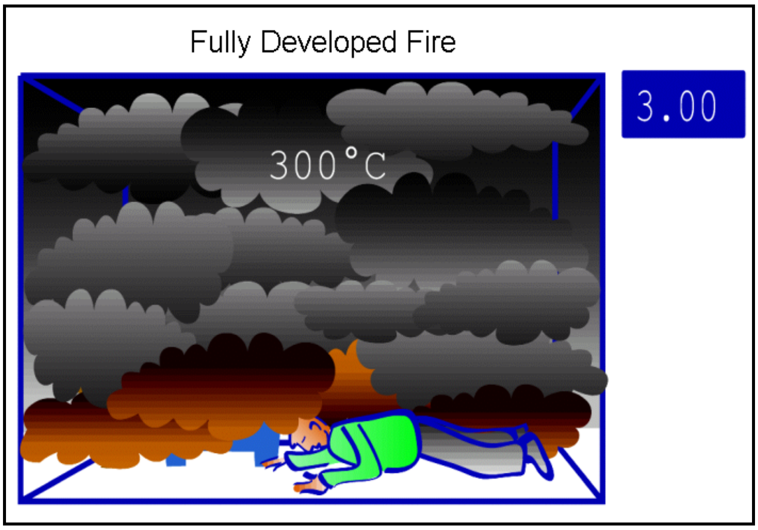


Figure 2.6: The fully developed fire.

Fire Precautions

Fire in an enclosure can be controlled by either passive or active fire precautions.

Passive fire precautions

Passive fire precautions include:

- The use of fire separating building structures
- The use of materials that are difficult to ignite or have low surface flame spread ratings.
- The use or storage of fewer combustible items and materials in the building.

Active fire precautions

- The use of sprinkler systems
- Automatic fire ventilation (AFV)

- Automatic door closing systems
- Automatic fire alarm system (AFA)

Both passive and active fire precautions may be modelled in Argos

Initial Fires

Argos includes seven types of fire growth simulations. These are:

- Solid material fire
- Melting material fire
- Liquid pool fire
- Liquid tank fire
- Smouldering fire
- Energy formula fire
- Data point fire (energy release rate versus time).

These types of fires are used to determine how the energy generation rate of the fire will be simulated.

Solid Material Fire

The solid material fire model is especially suited for modelling of fires in objects with a large void fraction, for example piles of pallets or storage racks with combustible goods, where the combustible materials are separated by air-filled spaces. The model is based on the following assumptions:

- The fire object has the shape of a box with a given height, width and length.
- The fire starts at floor level at the middle of the long side of the object.
- The velocity of horizontal flame spread is constant.

- Vertical flame spread increases exponentially.
- The rate of heat release per volume flame zone is constant.

For further information on the Solid Material Fire model, please refer to the Argos Theory Manual.

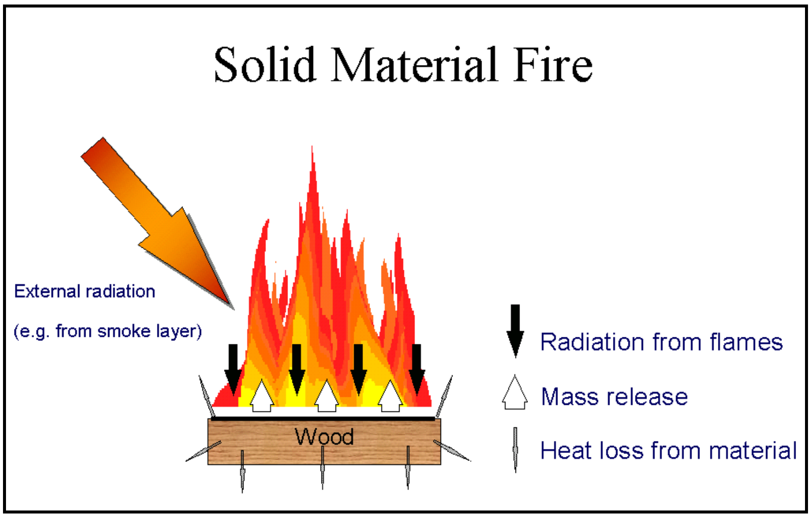


Figure 2.7: A solid material fire, burning wood.

Melting Material Fire

The model for fires in melting materials is especially suited for the modelling of fires in objects with a large void fraction, for example piles of polyethylene boxes, where the combustible materials are separated by air-filled spaces. The model is based on the following assumptions:

- The fire object has the shape of a box with a given height, width and length.
- The fire object will gradually melt and burn as a pool fire underneath the object.
- The fire starts at the middle of the long side of the object.

- The velocity of horizontal flame spread is constant.
- The rate of heat release per area flame zone is constant.
- The time interval from ignition of a partial area until the same partial area is burned out (i.e. the local burn out time) is proportional to the height of the object.

For further information on the Melting Material Fire model, please refer to the Argos Theory Manual.

Liquid Pool Fire

The model is based on fire in combustible liquid on a floor, where it will form a burning pool. The size of the pool and the effective heat of combustion determines the rate of heat release from the fire. The model also includes a minimum pool depth, which has a specific area for a given amount of fuel and a maximum fire area. The model limits the rate of heat release to a value corresponding to the smaller of the two areas. For further information on the Liquid Pool Fire model, please refer to the Argos Theory Manual.

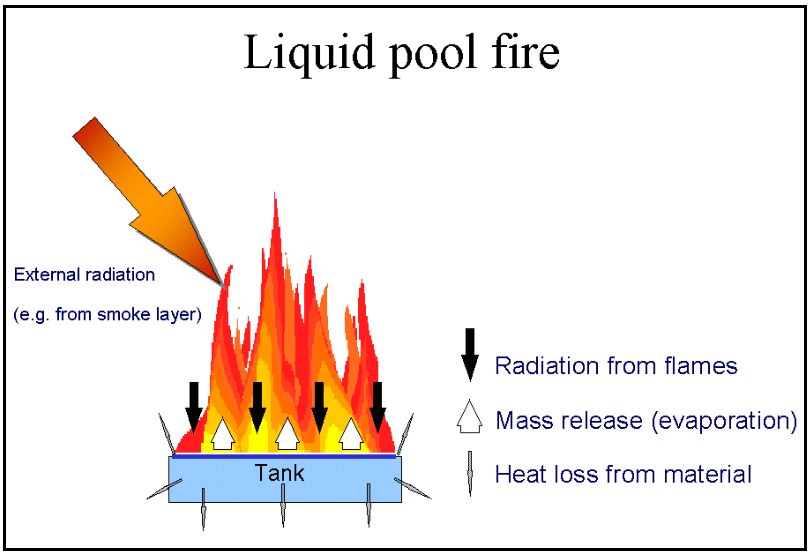


Figure 2.8: A liquid pool fire as oil burning in a tank.

Liquid Tank Fire

The model for liquid tank fires assumes that liquid is leaking from a vertical cylindrical vessel that has a hole in the bottom. The rate of leakage from the tank therefore decreases as the liquid level in the tank de-creases. As the liquid runs out of the tank, it forms a pool on the floor. The area of the pool depends on the rate of leakage, the depth of the pool, and the burning rate. The following assumptions are made:

- The liquid pool on the floor is ignited immediately when the leak starts.
- The rate of heat release per area pool is constant.
- The tank is open with vertical sides and horizontal bottom.
- The area of the pool is determined as either the specified maximum fire area or the calculated pool volume divided by the minimum pool depth, whichever is the smallest.

For further information on the Liquid Tank Fire model, please refer to the Argos Theory Manual.

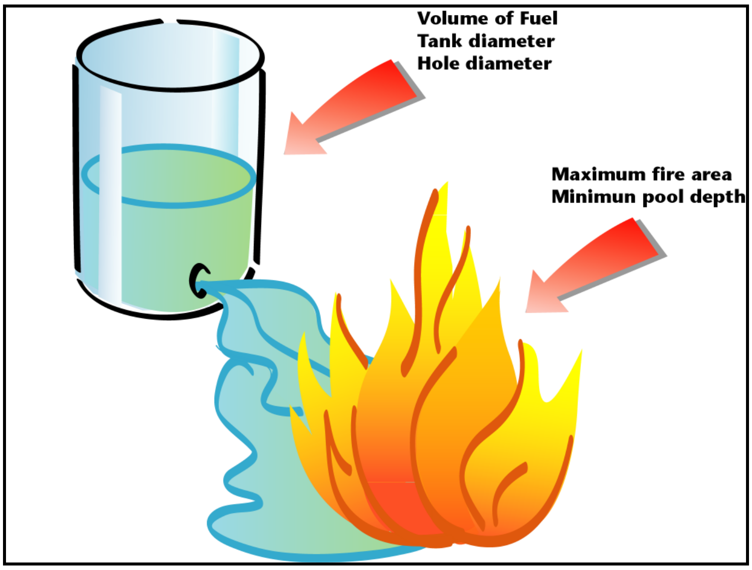


Figure 2.9: A liquid tank fire.

Smouldering Fire

The model assumes that the rate of heat release is equal to the specified constant value. A typical fire of this kind occurs when a cigarette is dropped onto a bed, which starts smouldering with a constant rate of heat release. This kind of fire is characterized by a low rate of heat release, which is seldom enough to create a smoke layer. Smouldering occurs without open flames, which gives poor and incomplete combustion of the burning items. This results in a high proportion of unburned and toxic gases as CO.

Energy Formula Fire

Two types of energy formula fires can be defined, fire development following second order polynomial or a doubling time formula.

The second order polynomial is the most typical and covers the often used "alpha t-squared-fire" where the fire develops with a heat release rate of $Q = \alpha \times t^2$. α is defined in four categories (see NFPA 204 M):

Growth Rate	α [kW/s^2]	Time [s] to reach 1055 kW
Ultra fast	0.190	75
Fast	0.047	150
Medium	0.012	300
Slow	0.003	600

The doubling time formula is used to enter a fire where the size is doubled with a fixed time interval. The input parameter is the size of the fire at the beginning and the doubling time.

Parameters for an Energy formula fire can only be changed in the database.

Data Point Fire

This fire type can be used to enter sets of time and heat release rate, so that any type of heat release curve can be used in the program.

This is typically used to enter data from tests where the heat release has been measured over a period of time. Argos comes with more than 200 predefined data point fires. Most of them have been taken from the *Initial Fires* report by Stefan Särdqvist. This report is included in the documentation for Argos. For more information, turn to the section *Additional information on Argos* in the *Introduction*.

Viewing a data point fire in Argos

The same fire codes that are used in the Initial Fires report can be found in Argos.

In order to view a data point fire in Argos, go to the *Fires* section in Database mode and click the **Code** field on the *Overview* tab. Then enter the code in the white **Search** field at the bottom of the page.

Chapter 3: Fire Simulation in Argos

This chapter provides a detailed description of how to use Argos for simulating a fire. It describes what you need to consider before setting up a scenario; how to create and run it; and finally how you may view and interpret the results.

Simulating a fire in Argos comprises the following stages:

- Specifying requirements based on the usage of the building
- Setting up the scenario (entering basic construction data)
- Running the scenario (making calculations)
- Viewing and interpreting the results (comparing the requirements with the calculated results).
- Customizing and re-running the scenario to get comparison results.

The Basic Requirements

As a first step, you need to draw up the overall requirements of the building. Where is the building to be located, what is it to be used for, how many rooms will it hold, what are the surroundings, etc.

Also, before entering data into Argos there are several things to consider in order to create the best possible scenario: What fires are likely to occur and what fire installations should be tested? Do the walls have any openings? Do they connect to other rooms? What are their geometry and location? Will any doors be opened/closed after a period of time?

Setting Up the Scenario

When *setting up the scenario* in Argos, you must create the scenario and then enter the various types of simulation data into Argos. These data may include (not all information is mandatory):

- Basic scenario information, such as scenario name, company type and construction information.
- The number of rooms and the basic geometry of each room — area and height.
- Information about doors, the walls connecting the rooms and the surroundings (materials used and wall lengths).
- Information about the ceiling and any openings in the ceiling (materials used and geometry).

Creating the Scenario

To create a scenario:

1. On the *Overview* tab, click the **Create** button. Argos then automatically opens the *General* tab. Enter the basic information about the scenario, such as shown in figure 3.1.

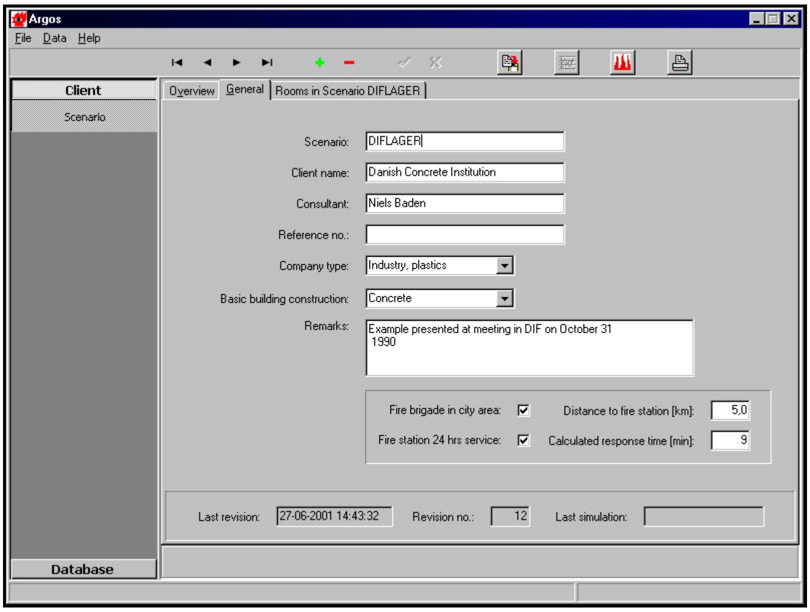


Figure 3.1: The General tab of a scenario

2. Click the **Save changes** button. A new tab labelled *Room in Scenario 1 Room* appears. This tab contains six subtabs:

    a. *Room Overview* — an overview of the scenario.

    b. *Room General* — used for defining the rooms (geometry, materials, etc).

    c. *Surfaces and components* — used for defining the walls, ceilings and openings.

    d. *Stocks* — used for defining the stocks in the rooms.

    e. *Machines* — used for defining machines in the rooms.

    f. *Fire installations* — used for defining fire installations in the rooms.

3. The scenario has now been created as a record in Argos.

Defining the Rooms

As described earlier, Argos allows you to model up to 5 different rooms.

To define a room:

1. Select the *Rooms in Scenario* tab.
2. On the *Room overview* subtab, enter the name of the room, its usage and geometry information, such as area and average height.

> **Note!** You can create new room usages in the Argos database. For more information, turn to *Chapter 7: Working in the Argos Database.*

3. The field **Max. distance** specifies the maximum horizontal distance from the fire origin to a corner of the room. In a fire which starts in the middle of a rectangular room, the max. distance should be set to half of the diagonal.

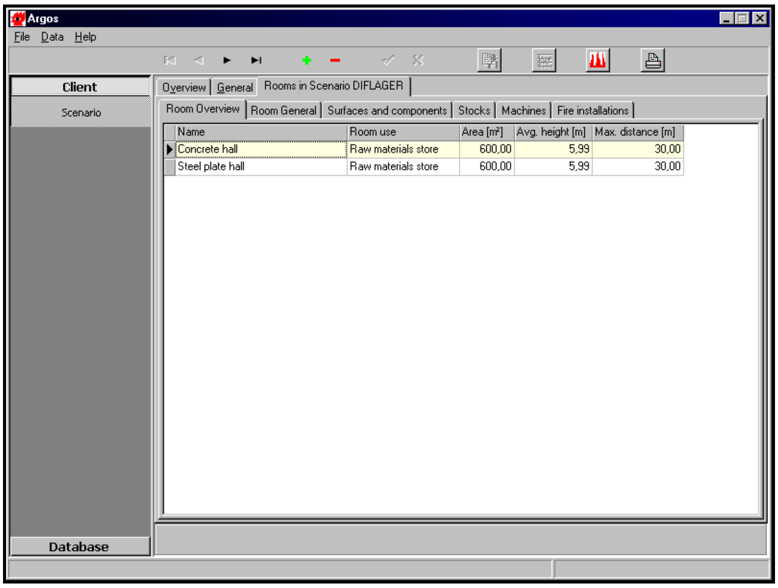


Figure 3.2: Overview of the rooms in a scenario.

4. Proceed to the *Room General* subtab to enter the floor type of the room.

5. Click the **Save changes** button to save your changes.

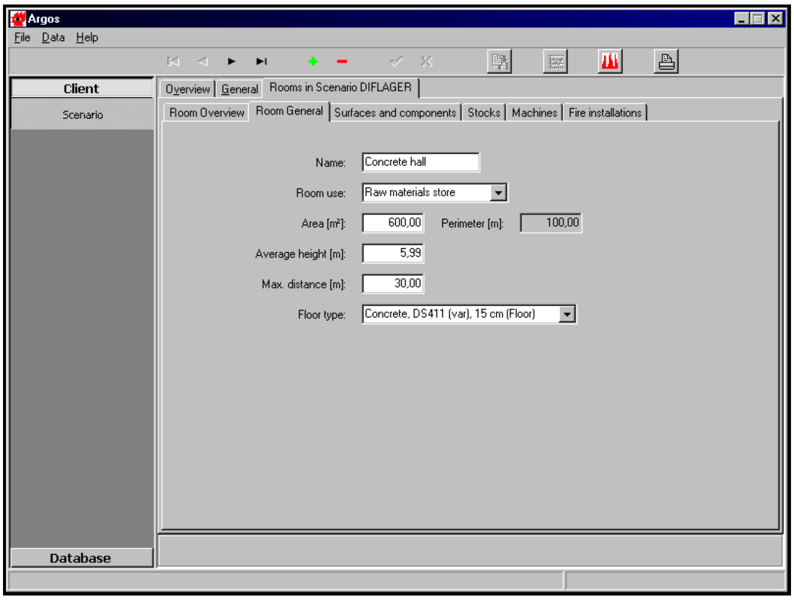


Figure 3.3: Basic information for a specified room.

For more information about the fields on the *Room overview Room General* tabs, turn to the Argos Help.

Defining Walls and Ceilings

Once the basic geometry information of the room is in place, you continue to enter information about the walls and ceilings of the room. It is also at this stage that you add openings such as doors, holes, etc.

Note!	You can create new walls, surfaces, ceilings and components in the Argos database. For more information, turn to *Chapter 7: Working in the Argos Database.*

To define the walls and ceilings:

1. Select the *Surfaces and components* tab.
2. On the *Walls* subtab, enter information about the walls in each room. Use the *Connected* check box to indicate that rooms are connected with each other via walls with or without doors or openings. Don't forget to indicate the length of each wall.
3. In the *Components* section of the *Walls* sub tab, enter information about any components in the wall, such as doors, windows, etc.

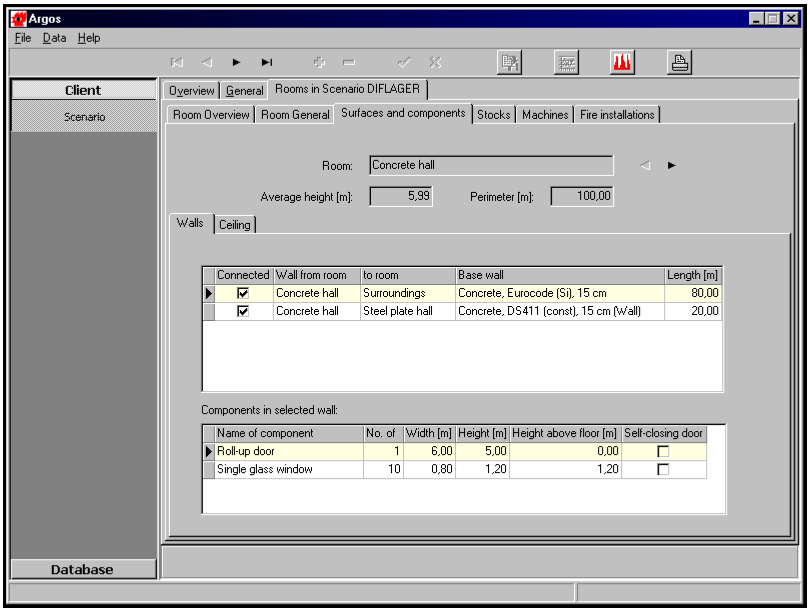


Figure 3.4: Overview of walls and their connections between rooms and surroundings. This is also where you can add a predefined opening within a wall.

4. Proceed to the *Ceilings* subtab to enter information about the ceiling in each room.
5. Click the **Save changes** button to save your changes.

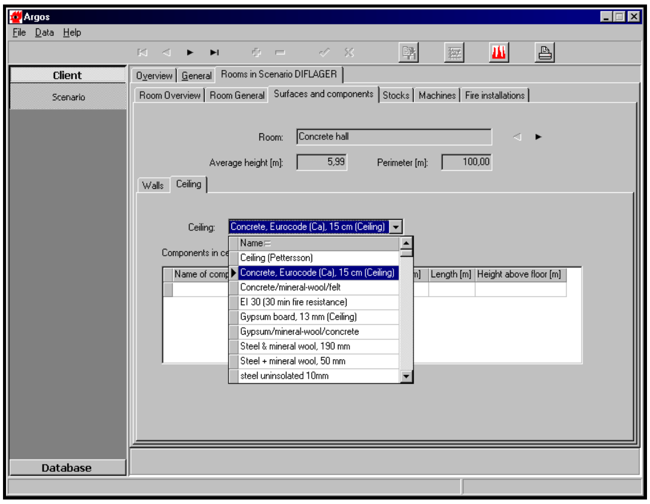


Figure 3.5: Selecting a predefined ceiling structure.

For more information about the fields on the *Surfaces and components* tab, turn to the Argos Help.

Defining Stocks and Machines

The next step is to indicate what type of stocks and machines the rooms will hold. This information is important since it will affect the conditions for the spread of fire in case of flash-over.

Note!	You do not need to enter information about stocks and machines in pure pre-flashover simulations.

To define the stock:

1. Select the *Stock* tab.
2. Select the relevant stocks for the room. The percentage figures entered in connection with stocks are your estimate of how much of the current material will cover the floor of the room.

Depending on the values entered, Argos will calculate the total price of the stocks and the total energy content (fire value), so the percentage figures can be adjusted to get the correct total fire value in the room. This is important to the development of the fire in a flashover scenario.

Furthermore, the prices are used to estimate losses due to fire (Damage report). Losses are calculated for both pre- and post flashover fires.

> **Note!** Stocks will only burn in fires which flashover, so the fire value of stocks is only important in these cases.

3. Click the **Save changes** button to save your changes.

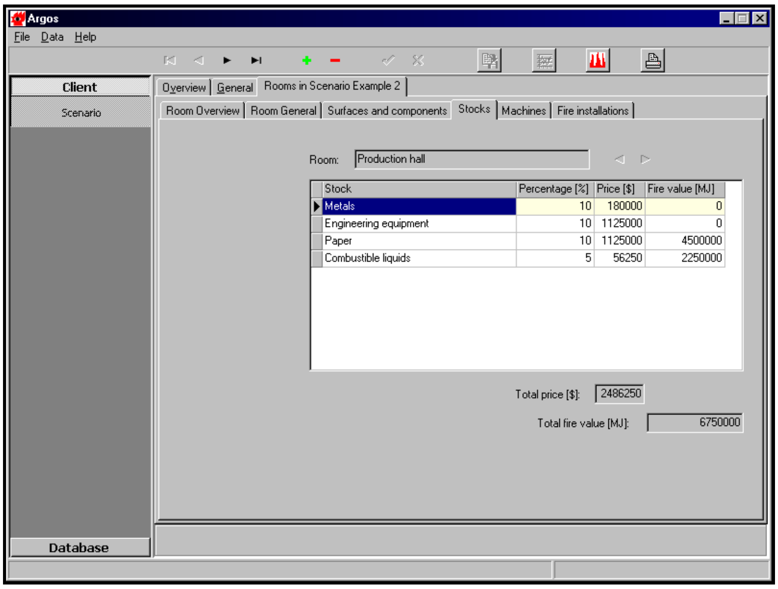


Figure 3.6: Selecting predefined stocks for a given room.

For more information about the fields on the *Stocks* tab, turn to the Argos Help.

To define the machines:

1. Select the *Machines* tab.
2. Select the relevant machines for the room. The percentage figures entered in connection with machines are your estimate of how many machines there will be in the room.

   Depending on the values entered, Argos will calculate the total price of the machines. This is used for estimating the loss in case of fire (Damage report), calculated for both pre- and post flashover fires.

Note!	The fire value of the machines (in the database) is not added to the total fire load and has no influence on the calculations.

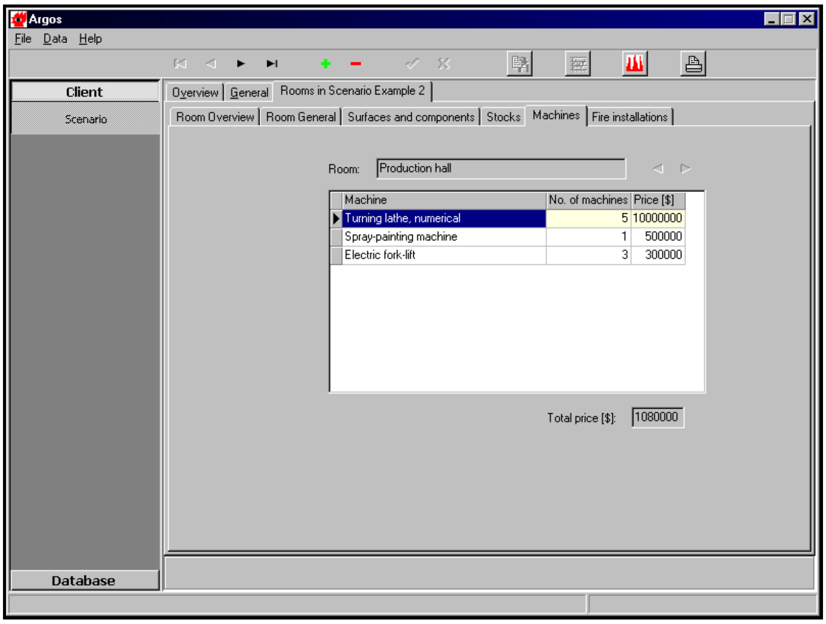


Figure 3.7: Selecting predefined machines for a given room.

3. Click the **Save changes** button to save your changes.

For more information about the fields on the *Machines* tab, turn to the Argos Help.

Defining Fire Installations

Working with fire installations in Argos is one of the core areas, since this is where you can adjust how the fire will be controlled during the simulation. Fire installations include automatic smoke detectors, automatic heat detectors, automatic smoke venting devices, and sprinklers.

Note!	Once activated, you may toggle fire installations on and off prior to performing the actual simulation, in order to view the differences in the results. For more information, turn to the section *Customizing the Scenario* later in this chapter.

An important note on sprinklers and automatic fire ventilation (AFV): If you choose to employ both sprinklers and AFV, make sure to select a sprinkler with a response time index (RTI) value which is less than the RTI value of the AFV. If the RTI value of the AFV is lower than the similar sprinkler value, the AFV might be released before the sprinkler, which could delay the activation of the sprinkler.

To define fire installations:

1. Select the *Fire installations* tab. The *Overview* subtab contains a summary of the five adjacent tabs.
2. Select the relevant fire installations.
3. Click the **Save changes** button to save your changes.

   For more information about the fields on the *Fire installations* tab, turn to the Argos Help.

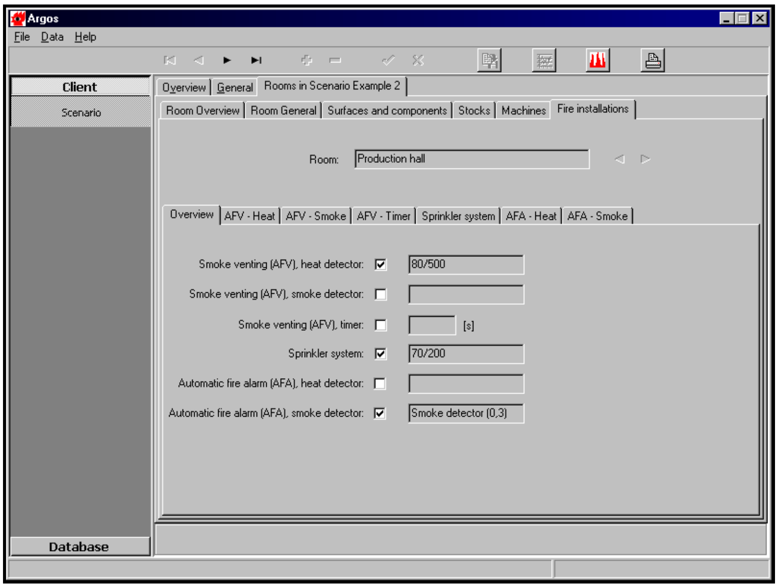


Figure 3.8: Selecting predefined active fire precautions, i.e. automatic fire ventilation (AFV) triggered either due to smoke or heat.

Once you have run a simulation, you may go back and change the input data and launch a new simulation for the current scenario. For instance, you can see how the simulation changes if you install another fire installation, or choose to install self-closing doors.

Running the Scenario

Once you have created the scenario, you are ready to run it, i.e. perform the actual fire simulation. When running the scenario, you choose an initial fire. Argos then calculates how temperatures and smoke develop.

1. Click the **Simulate fire** button. This will open the **Simulate fire** window.

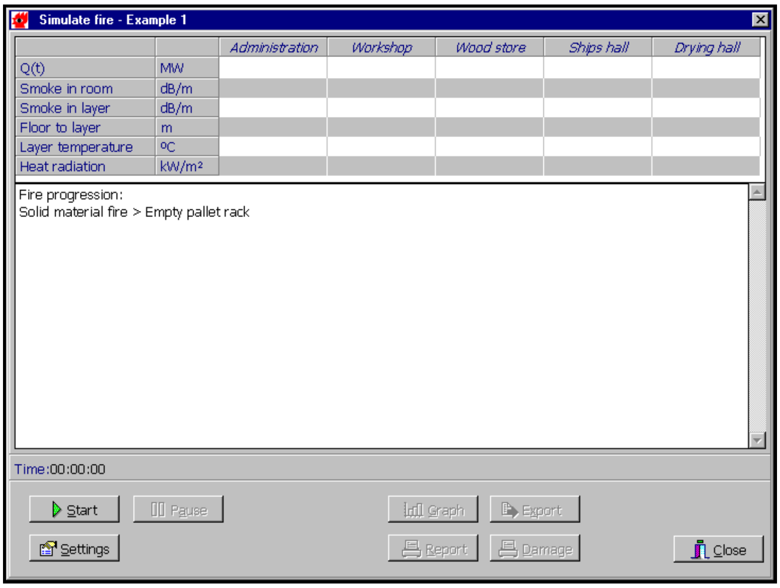


Figure 3.9: The Simulate fire window in which you launch the scenario.

2. If you wish to use the default initial fire suggested by Argos, click **Start** to run the scenario. Argos allows you to run the same scenario with different initial fires. For more information, turn to the *Selecting a Room and an Initial Fire* section later in this chapter.

3. Depending on how the scenario is set up, the simulation stops when the fuel has burned or when the fire brigade puts out the fire. The result is displayed in the **Simulate fire** window.

   You may then proceed to view the graphs and reports generated by Argos. Alternatively, choose to customize the scenario and run it again.

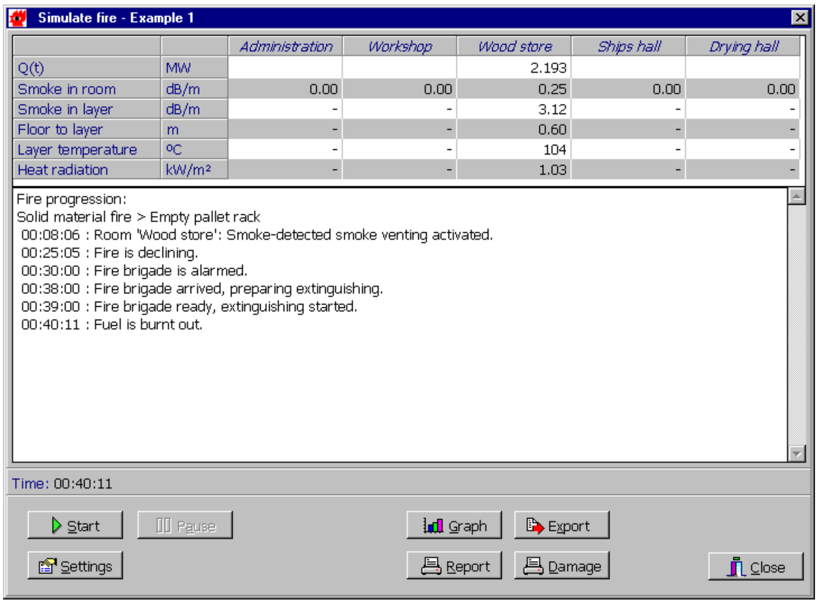


Figure 3.10: The Simulate fire window after a simulation.

Customizing the Scenario

Argos allows you to set various simulation options prior to running a scenario.

For instance, you can select which initial fire to use in the scenario. If the first fire chosen does not fully provide the answers you are seeking, choosing another fire might give you the desired result.

Note!	You can create your own fires in Database mode. For more information, turn to *Chapter 7: Working in the Argos Database.*

Argos also allows you to turn the manual alarm of the fire brigade on and off, which will influence the time it takes for the fire brigade to arrive on the scene. If, for instance, you extend the brigade's time of arrival, a powerful fire will burn longer and give you relevant information about damaged stock and machines.

> **Note!** Argos cannot predict exactly how the fire brigade will try to extinguish the fire brigade i.e. how many fire fighters are needed or estimate the amount of water which is necessary for putting out the fire.
>
> In the simulation, the time to extinguish the fire depends on the size of the fire. After flash-over, neither the fire brigade nor the sprinkler system can extinguish the fire.

You can turn fire installations on and off to see the impact on the results. What happens if you turn off automatic fire ventilation while keeping the sprinkler systems? Or vice versa?

Finally, you can choose to have the doors open or closed during the simulation or perhaps turn self-closing doors on and off.

The purpose of customizing the scenario is simply to change the circumstances for the fire. Changing these settings while running the simulation several times allows you to get the best possible results and help you in your analysis and conclusion-making.

Customizing the Simulation Model

Argos allows you to customize how the simulation is executed in various ways:

To customize the simulation model:

1. In the **Simulate fire** window, click **Settings** to open the **Simulation options** dialog box.
2. Selecting the *Enable post flash-over model* check box means that Argos will continue the calculation after the flash-over has occurred in a room. After the flash-over, the calculation will only apply to the room in which flash-over occurred.

3. Selecting *Stop on event* check box specifies that the program will pause at critical points and display a message, e.g.: "Fire is declining" or "Flash-over in room 4". The program will pause until the user responds to the message by clicking **Resume**.

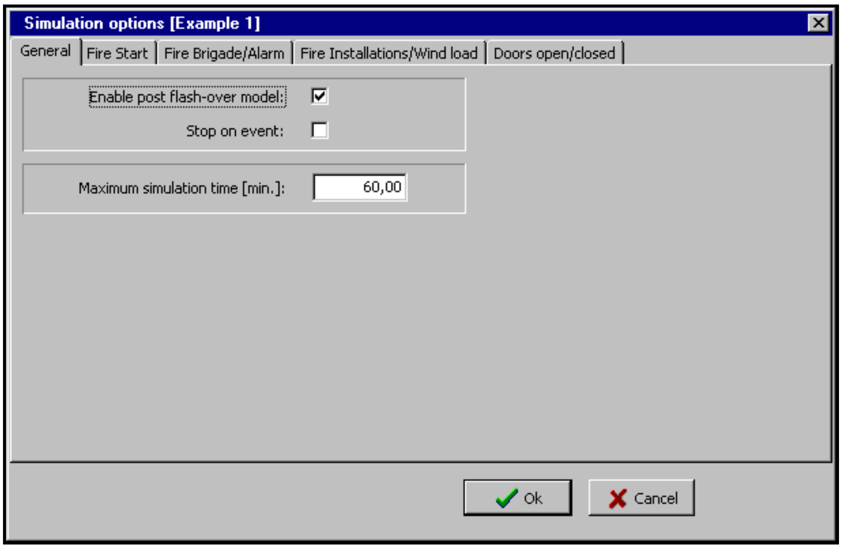


Figure 3.11: The General tab of the Simulation options dialog box.

For more information about the customisation options on this tab, turn to the Argos Help.

Selecting a Room and an Initial Fire

Use the *Fire Start* tab in the **Simulation options** dialog box to set various options related to the initial fire and the room in which it starts.

To select a room and an initial fire:

1. In the **Simulate fire** window, click **Settings** to open the **Simulation options** dialog box.

2. On the *Fire Start* tab, choose the room in which the fire will start from the *Fire start in room* drop-down list box.

3. On the *Fire start name* drop-down list box, select the name of the fire, and then select a fire type in the adjacent field.
4. Adjust the parameters of the fire in the *Height*, *Width*, and *Length* fields. (Note that not all fire types include these parameters.)
5. Select the *Keep current fire* check box if you wish the selected fire to be used with every simulation in the current scenario. Click the *Use default fire* button to have Argos revert your selection of fire to the Argos default fire. The default fire used will depend on your selection for company type and room use.

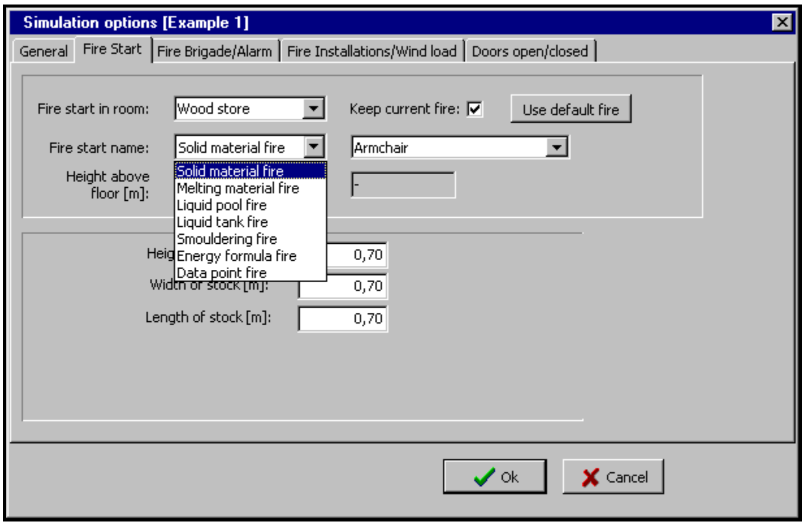


Figure 3.12: Use the Fire Start tab of the Simulation options dialog box to select an initial fire.

For more information about the customization options on this tab, turn to the Argos Help.

Turning Manual Alarm On and Off

Argos enables you to specify that a person alarms the fire brigade after a certain period of time.

To turn manual alarm on and off:

1. In the **Simulate fire** window, click **Settings** to open the **Simulation options** dialog box.
2. On the *Fire Brigade/Alarm* tab, set the Manual alarm to disabled or enabled, and enter a relevant figure in the *Delay* field.

   For more information about the customisation options on this tab, turn to the Argos Help.

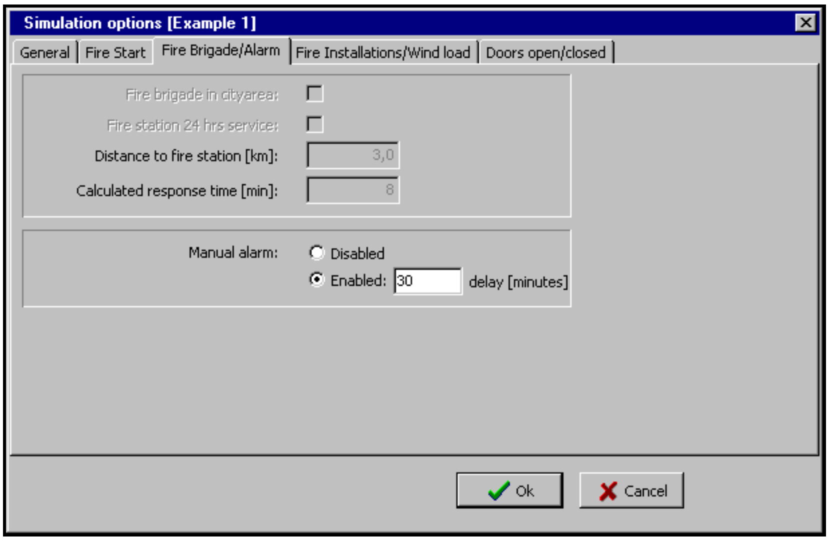


Figure 3.13: The Fire Brigade/Alarm tab of the Simulation options dialog box.

Turning Fire Installations On and Off

Argos enables you to turn fire installations on and off to see the impact on the results. This option requires that you have defined the fire installations beforehand when setting up the scenario.

To turn fire installations on and off:

1. In the **Simulate fire** window, click **Settings** to open the **Simulation options** dialog box.

2. On the *Fire Installations/Wind load* tab, select the room in which you wish to toggle fire installations on and off. Then deselect or select the relevant fire installations.
3. The *Wind speed* option allows you to enter a figure for the wind speed. The default value for wind speed is 0 m/s, and a typical value to enter is 5 m/s. The wind speed can affect smoke spread and smoke venting. Please refer to figures 3.15 and 3.16.

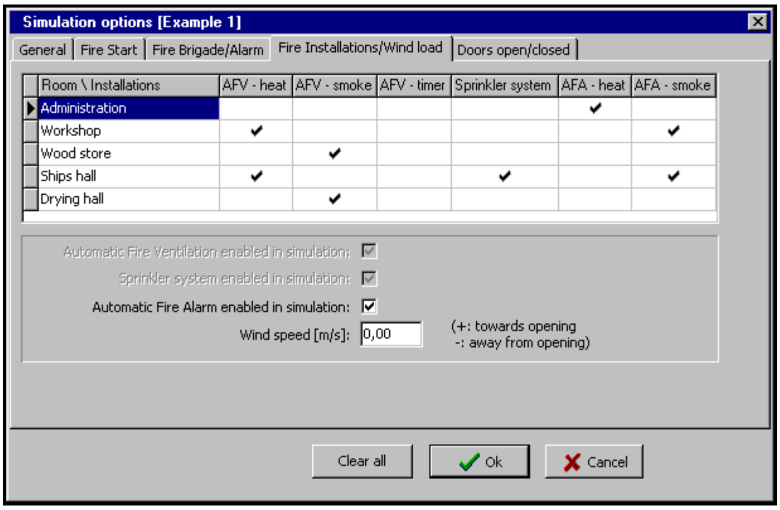


Figure 3.14: The Fire Installations/Wind load tab of the Simulation options dialog box.

For more information about the customisation options on this tab, turn to the Argos Help.

The Effect of the Wind on the Simulation

How does wind affect a simulation? In figure 3.15, wind passing through a fire room can lead to increased smoke spread to adjacent rooms, especially if no smoke layer is formed. This means that the smoke is cold and will not move by itself. So here wind will worsen smoke spread. The simulation is more reliable when a wind speed other than zero is chosen.

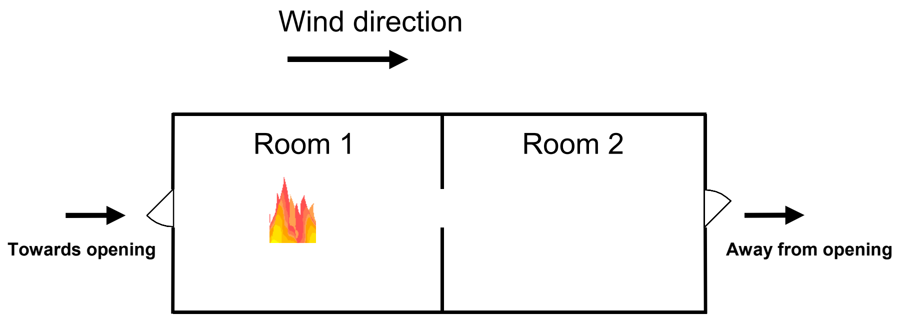


Figure 3.15: Wind towards the opening forces smoke to the next room.

In figure 3.16, the effect of smoke venting is shown with wind towards the opening. This will improve the venting of the hot gasses compared to when there is no wind towards the opening. In other words, wind will lead to a less reliable simulation.

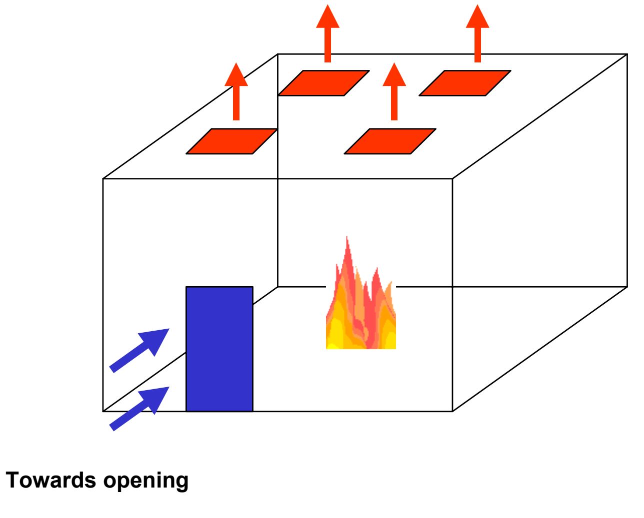


Figure 3.16 Wind towards the opening enhances smoke venting.

Opening and Closing Doors

Argos allows you to control the opening and closing of doors. Initially, this is defined as part of setting up the scenario but using the **Simulation options** dialog box you may customise door behaviour in various ways.

To customise door behaviour:

1. In the **Simulate fire** window, click **Settings** to open the **Simulation options** dialog box.
2. On the *Doors open/closed* tab, select the *Door is closed initially* option. A closed door will result in more smoke in the room — not more heat.
3. In the *Self-closing door activated* option, select any self-closing doors to be activated by timer or by detectors.

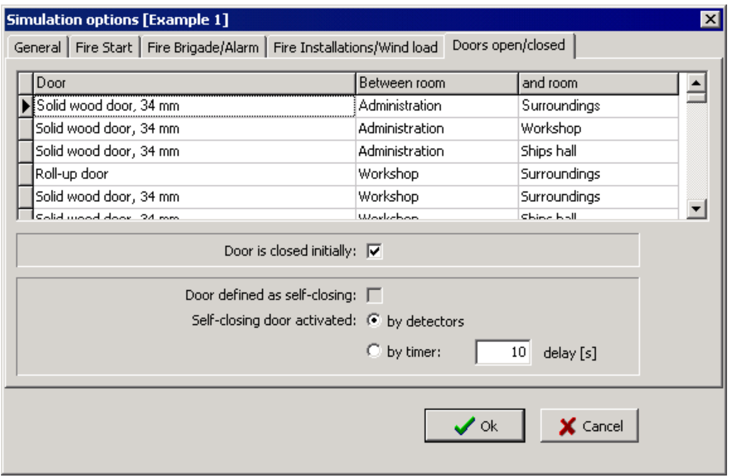


Figure 3.17: Use the Doors open/closed tab to control the opening and closing of doors.

For more information about the customisation options on this tab, turn to the Argos Help.

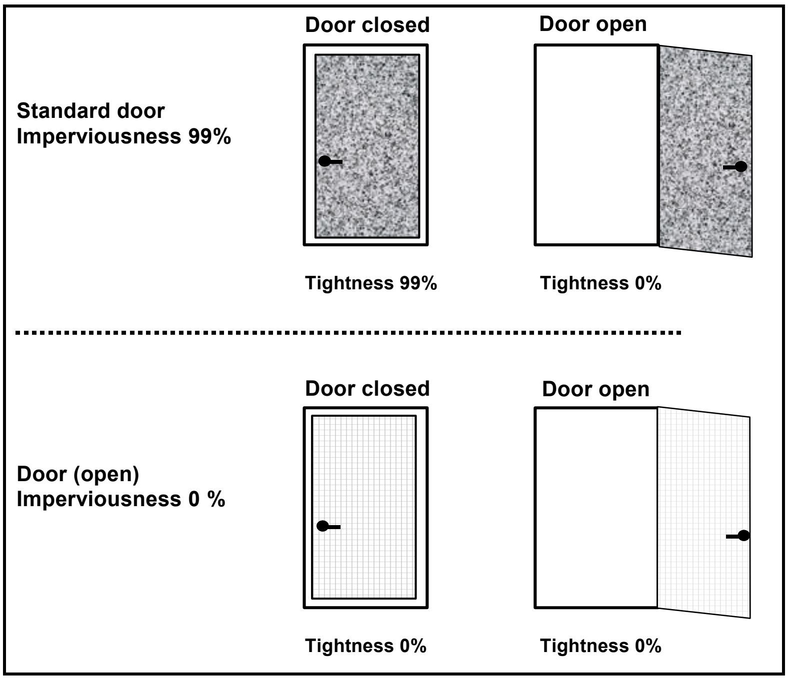


Figure 3.18: Open and closed doors.

Since doors are not totally leakproof, all doors in Argos are defined with a certain amount of leakage. This will insure that there is always a small opening to the surroundings, which is also a requirement for a simulation. In other words, it is not possible to launch a simulation in Argos unless there is an opening to the surroundings.

The default leakage value for a door is 1%. This means that 99% of the door is blocked. In Argos, the amount of blockage is referred to as *imperviousness*. Every door in the Argos database has an imperviousness value attached.

When a door with an imperviousness value of 99% is *closed,* then the tightness of the door is 99%. When the door is *open,* the tightness is 0%. This is illustrated in the upper part of figure 3.18.

To avoid having to open all doors prior to a simulation (for instance when it is known in advance that the doors will be permanently opened) you can select a door in the database, which has an imperviousness value of 0%. You find these doors indicated by the string "(open)" at the end of the door name. These doors always have a tightness of 0% (always open), no matter if they are *closed* or *opened*. This is shown in the lower part of illustration 18.

Post-processing the Simulation Results

Output from Argos comes in the form of graphs, a data file and a report. All three options are available from the **Simulate fire** window, once the simulation has been run.

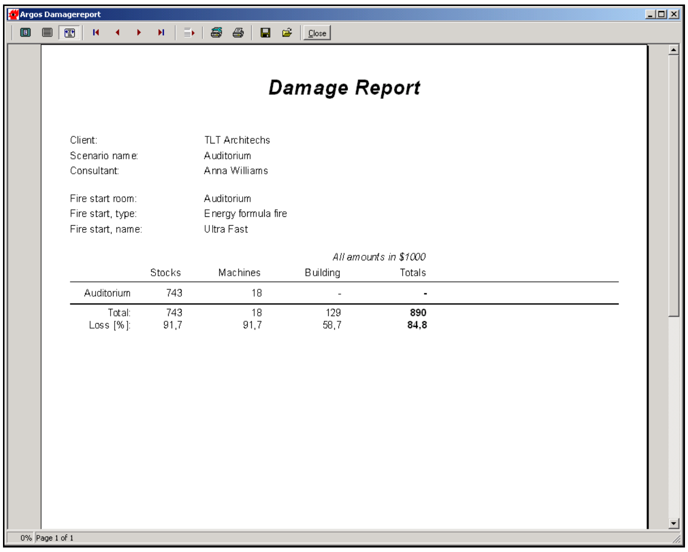


Figure 3.19: An Argos Damage report.

- To display the graphs of the simulation, click the **Graphs** button. For a detailed description of the graphs in Argos, turn to *Chapter 5: Graphs in Argos*.
- To export the simulation results to a text file, click the **Export** button.
- To print a scenario report, click the **Report** button.

- To print a damage report, click the **Damage** button. The report shows the estimated damage costs to stocks and machines in case of a flash-over fire.

Copying a Scenario

Argos provides a means for copying information from one scenario to a new scenario. With this time saving feature, you can re-use all default values of an existing scenario.

To copy a scenario:

1. In the main window, select the scenario you wish to copy.

1. On the toolbar, click the **Copy scenario** button. The **Name of new scenario** dialog box opens.

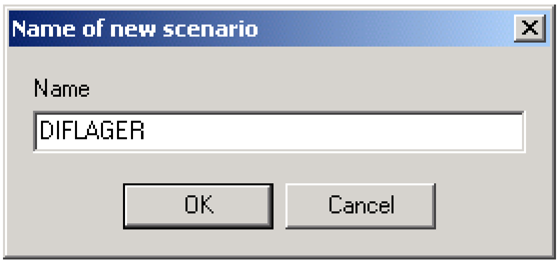


Figure 3.20: Enter a name for the new scenario.

2. Enter the new name and click **OK**. The new scenario is inserted in the main window.

3. Proceed to the tabs of the new scenario and make the necessary adjustments.

4. Click **Save changes**.

Chapter 4: Case Scenarios

This chapter presents a series of eight different case scenarios, which describe how Argos can be used for fire simulation in various circumstances.

The scenarios are:

- The Auditorium
- The Auditorium – Smoke Venting Installed
- The Auditorium — Sprinkler System Installed
- The Auditorium — AFA Smoke Detector Installed
- The Auditorium with Corridor
- The Auditorium with Corridor – Self-Closing Doors
- The Sports Arena
- The Auditorium – Pre- and Post-Flash-over Calculations

I The Auditorium

In this case scenario, TLT Architects, architects and consulting engineers, are bidding for a new auditorium to be built for a large company in the service industry. The auditorium will be used for educational purposes such as seminars and conferences. The auditorium will seat up to 100 persons. As part of the bid material, TLT Architects needs to assess the fire safety of the building. The auditorium is to be built at the Danish Institute of Fire and Security Technology (DIFT).

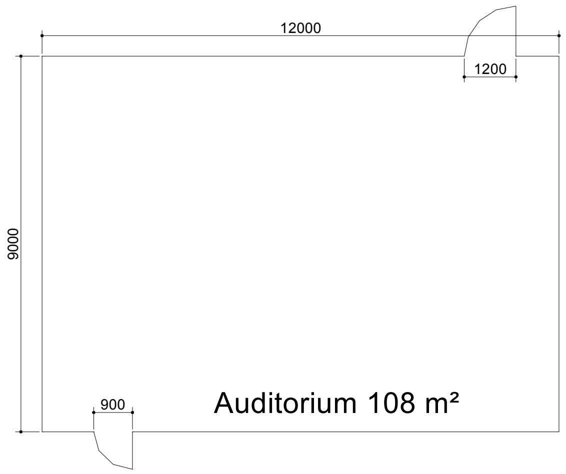


Figure 4.1: Drawing of the auditorium at the Danish Institute of Fire and Security Technology (DIFT). All measurements in millimetres.

The following information is available:

- The auditorium area totals 108 m^2 and the average height is 4 meters.
- The basic building construction is brick wall with a concrete roof. The floor is timber.
- The auditorium has two doors, a 100 mm thick steel door and a solid wood door, which leads to the surroundings.

♦ The nearest fire brigade is 3.5 kilometres away. Situated in the city area, the fire station is permanently staffed.

Creating the Scenario

The first step is to create a new scenario in Argos:

1. Click the **Create** button and enter the following information on the *General* tab:

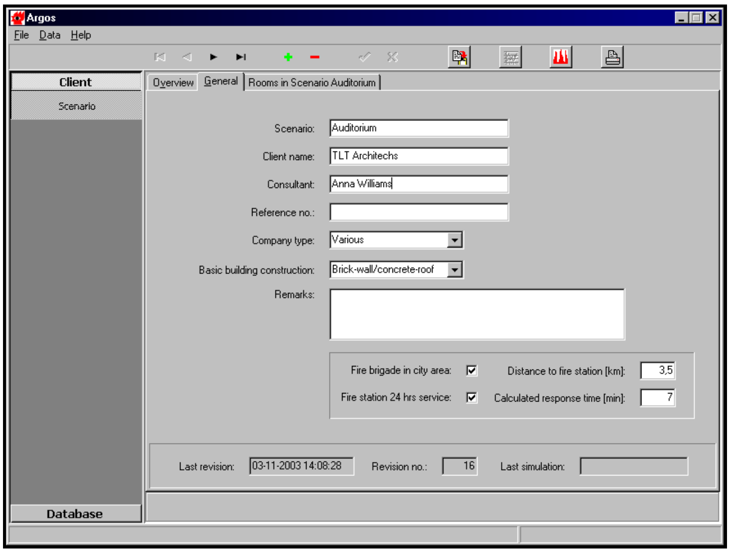


Figure 4.2: The General tab.

2. Click the **Save changes** button. A new tab labelled *Room in Scenario 1 Room Auditorium* appears.

3. On the *Room Overview* tab, enter the basic physical information of the room such as name, room usage, area height and max. distance.

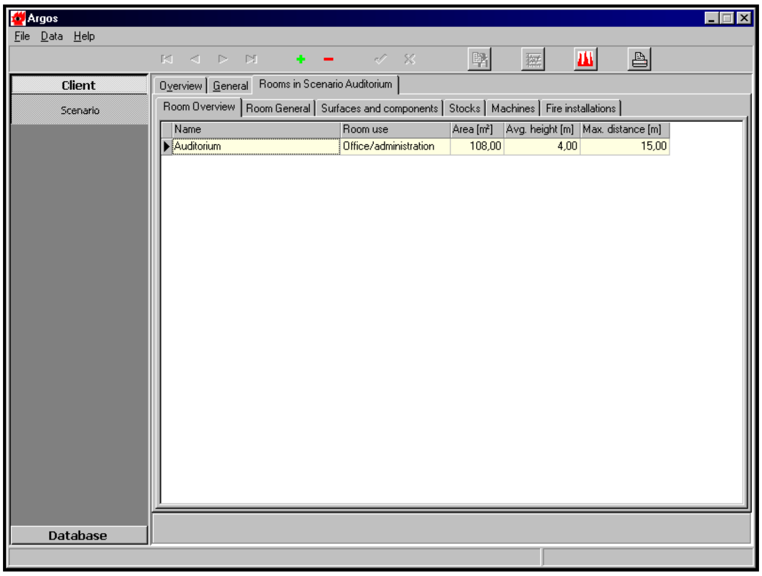


Figure 4.3: The Room Overview tab.

4. Proceed to the *Surfaces and components* tab. On the *Walls* subtab, enter the doors (components) in the walls between the room and the surroundings, as shown in figure 4.4.

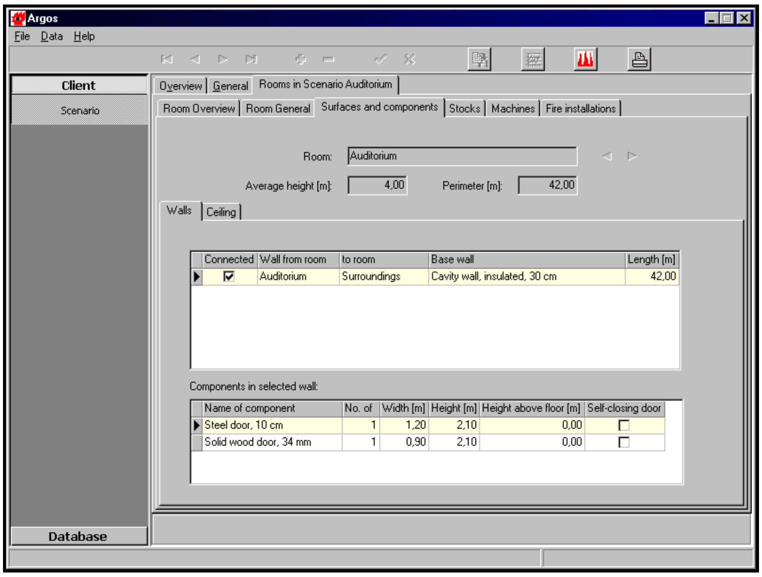


Figure 4.4: The Surfaces and components tab –Walls subtab.

5. The ceiling is identified as a *Gypsum/mineral/concrete* type of ceiling. There are no additional components in the ceiling. On the *Ceilings* subtab, enter the type of ceiling, as shown in figure 4.5. Components, such as skylights, can be subsequently added.

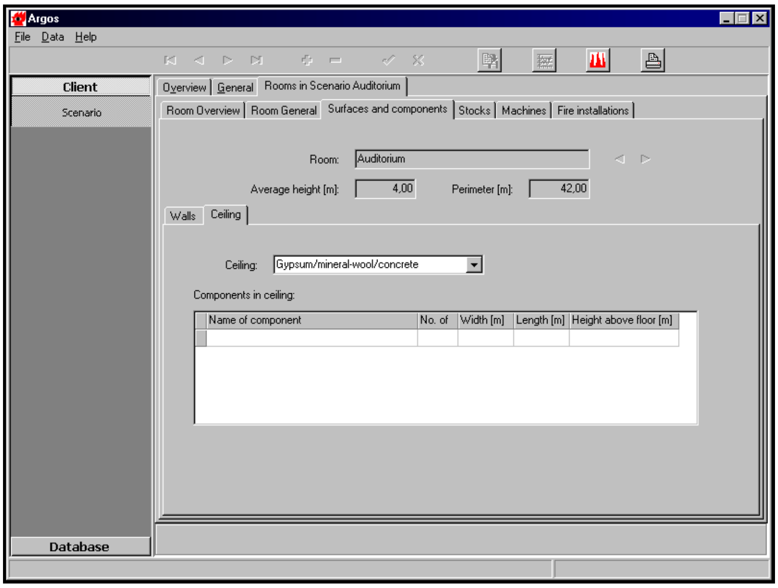


Figure 4.5: The Surfaces and components tab –Ceiling subtab.

6. The *Stocks* tab enables you to enter information about any stock in the room. In this model, we assume that there is a stock of paper, which covers 5% of the floor.

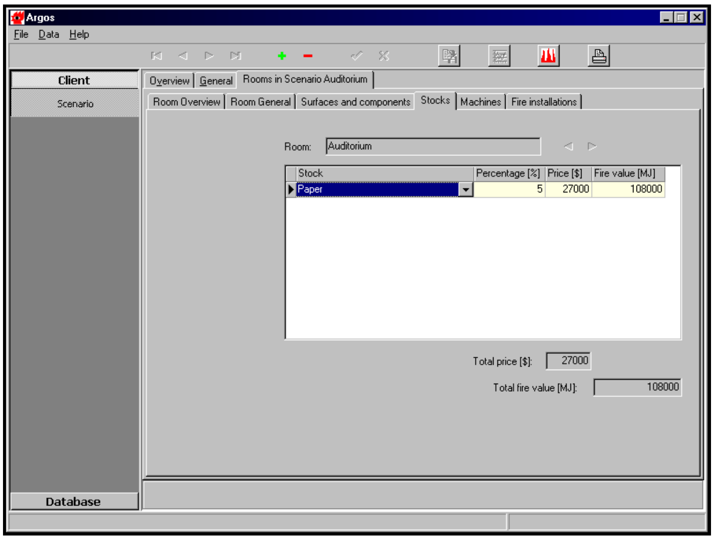


Figure 4.6: The Stocks tab.

7. Delete all machine entries on the *Machines* tab. In this scenario, no machines are considered possible fire sources.

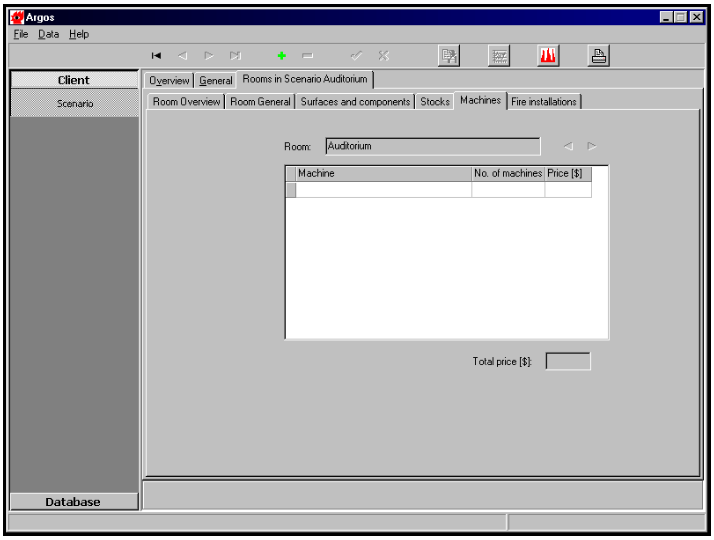


Figure 4.7: The Machines tab.

8. Leave the *Fire installations* tab empty. We will include fire installations in case scenarios 2-4.

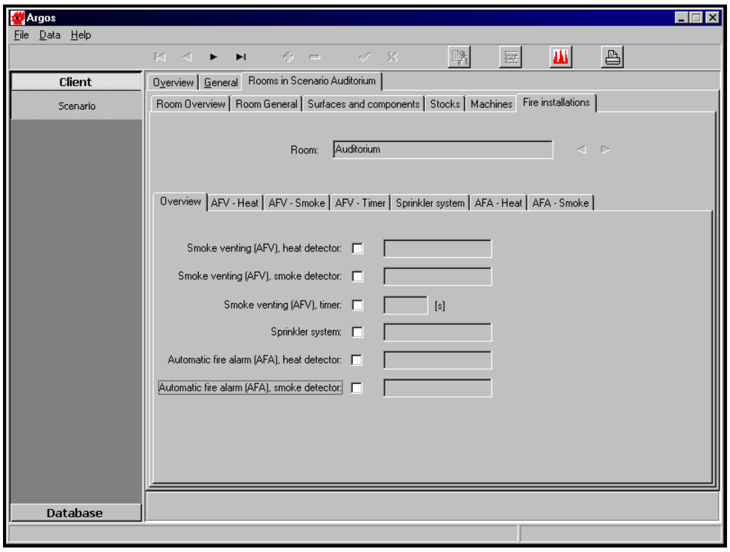


Figure 4.8: The Fire Installations tab.

9. You have now entered all the information for the Auditorium scenario and may proceed to run it.

Running the Case Scenario

The first step in running the scenario is to choose a plausible fire.

The auditorium is equipped with various items, which may initiate a fire under the right (wrong) circumstances: An overhead projector, an electricity supply panel and a waste paper basket. Each of these fire sources will produce a different fire.

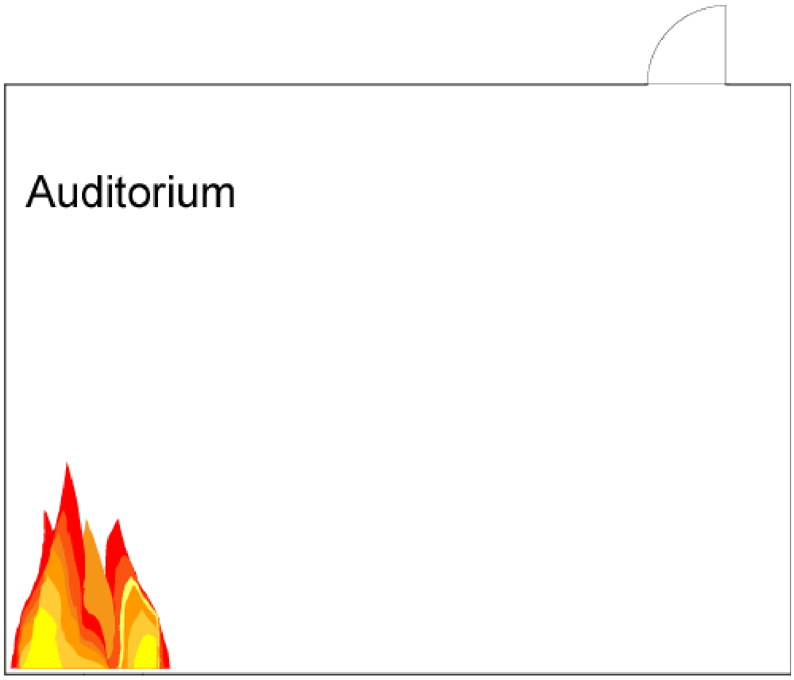


Figure 4.9: The fire starts in a waste paper basket located in the corner of the auditorium. The Max. distance is 15 meters.

In this scenario we will use a fire in a waste paper basket:

1. On the toolbar, click the **Simulate fire** button. Argos will load the scenario information and prepare it for launch. The **Simulate fire** window opens.
2. Click the **Settings** button to open the **Simulation options** dialogue box. On the **Fire Start** tab, set the fire type to *Energy formula fire* and select the *Waste paper basket* fire (a fast fire with a maximum of 0.5 MW).

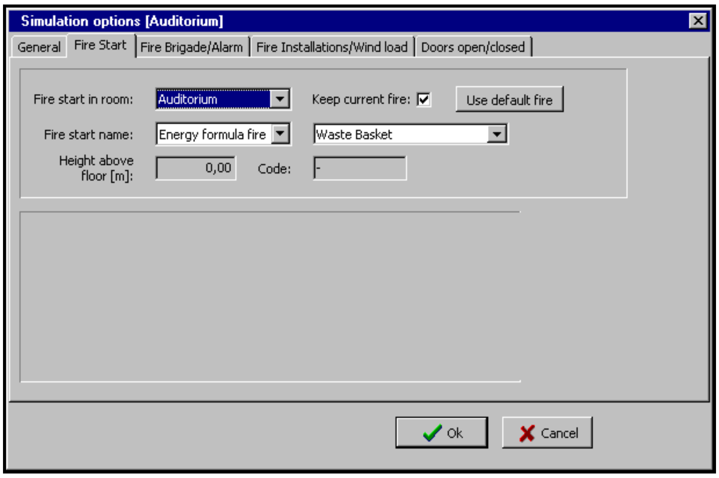


Figure 4.10: Use the Simulation options dialog box to select an initial fire.

3. Click **Start**. Note the status area as the fire progresses. The figure below shows the key points in the development of the fire. Note that the fire brigade is alarmed after 10 minutes. After 18:45 minutes, the fire has been put out.

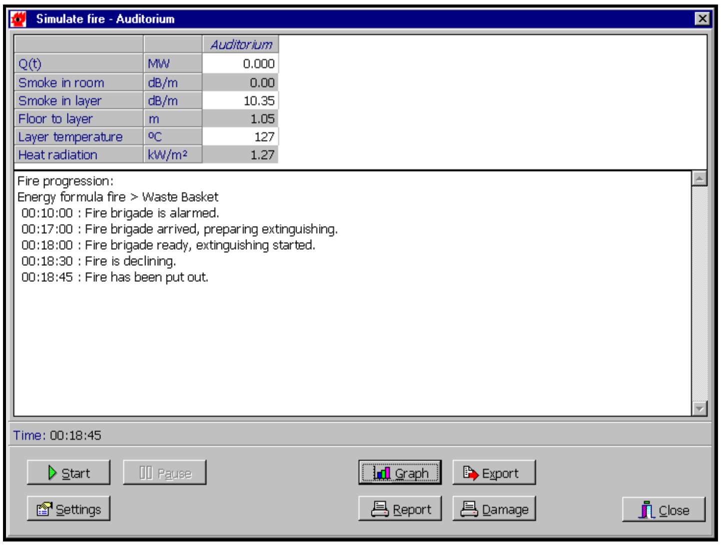


Figure 4.11: The Simulate fire window will show the events for the simulation.

Interpreting the Results

Since the auditorium will often be used by many people, one of the main purposes of running this scenario is to estimate when critical conditions occur. In particular, the following graphs are of interest:

- Rate of heat release from fire
- Optical smoke density in rooms
- Distance from floor to smoke layers

Rate of heat release from fire

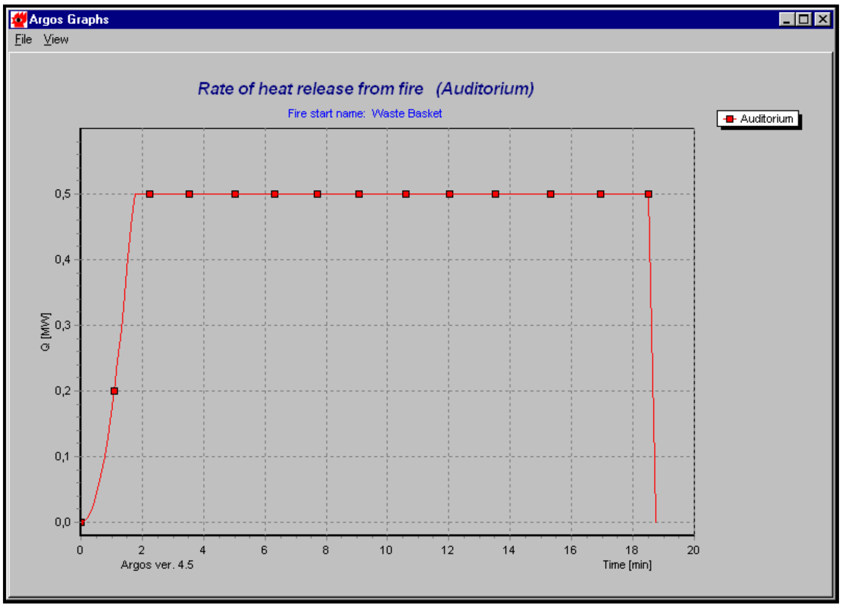


Figure 4.12: The Rate of heat release from fire graph.

The **Rate of heat release from fire** graph shows a drastic increase in heat release over the first couple of minutes. and it reaches its highest level of 0.5 MW after approximately 1:50 minutes. For the remainder of the fire, the rate of heat release is constant.

When the fire brigade arrives, the fire is extinguished in 45 seconds.

Optical smoke density in rooms

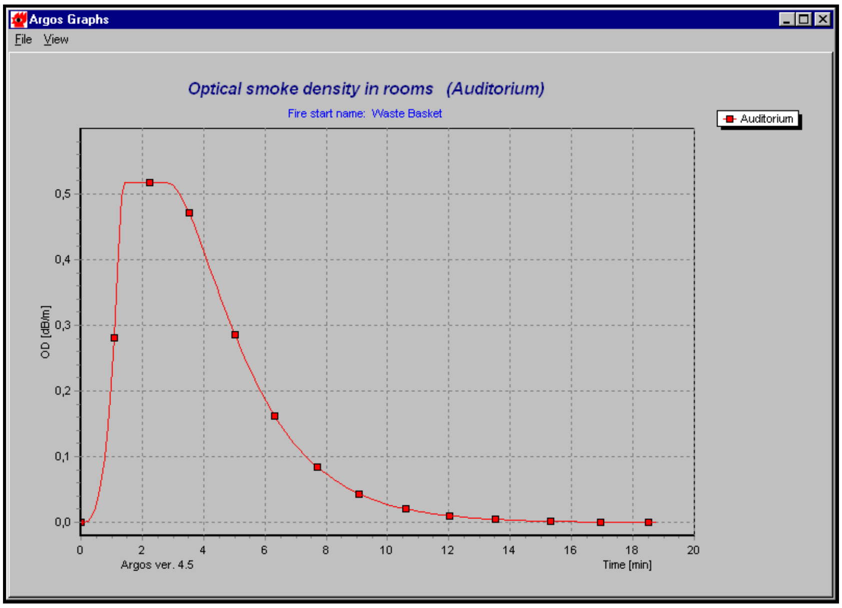


Figure 4.13: The Optical smoke density in rooms graph.

The **Optical smoke density in rooms** graph shows that there is a drastic increase in smoke density in the first two minutes followed by a constant period for approximately 1 minute, after which the density gradually decreases during the remaining course of the fire.

The highest level of OD is 0.55 dB/m and this shows that the lowest visibility is 18 m (Visibility = 10/0.55 ≈ 18 m). The formula for visibility is *Visibility = 10/OD*.

As the visibility does not drop below 10 meters, critical conditions do not occur.

Distance from floor to smoke layers

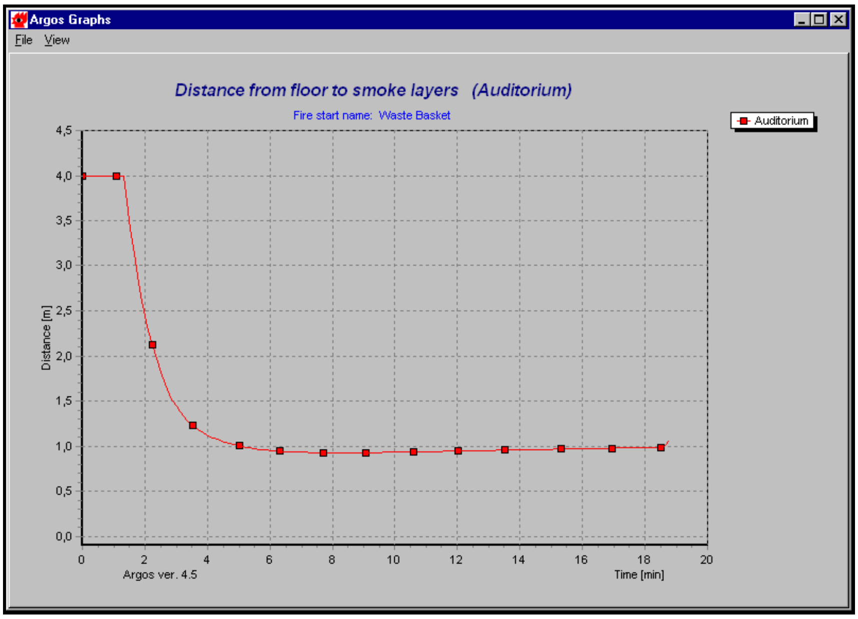


Figure 4.14: The Distance from floor to smoke layers graph.

The **Distance from floor to smoke layers** graph shows that the distance from floor to smoke is drastically reduced in the period between 1 minute and 6 minutes.

Critical conditions occur after 2.5 minutes, at which point the smoke layer decreases below 2 meters (1.6 m + (0.1 x 4 m)). After 6 minutes, the height is approximately 1 meter.

II The Auditorium — Smoke Venting Installed

In this scenario, we will run the Auditorium scenario with smoke venting devices installed. This means that the smoke will be transported through roof vents that open automatically. The objective is to see how this temperature in the auditorium will be affected.

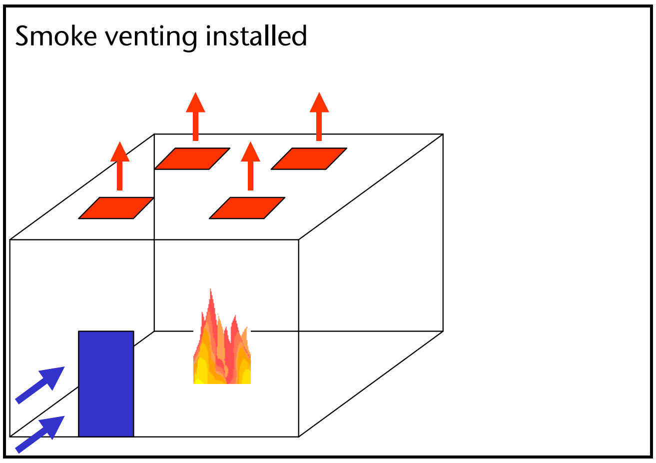


Figure 4.15: Scenario with automatic smoke venting installed.

Creating the Case Scenario

Since we have already created the Auditorium scenario, we simply need to update it with information about the smoke venting device:

To add the smoke venting device:

1. Select the scenario in the Scenario pane, and go to the *Rooms in Scenario* tab.
2. Select the *Fire installations* tab.
3. On the *AFV - Smoke* tab, add the following information and click the **Save changes** button to save your changes. In the **Total opening area [m^2]** field, enter 3 m^2, which corresponds to approximately 3 % of the floor area.

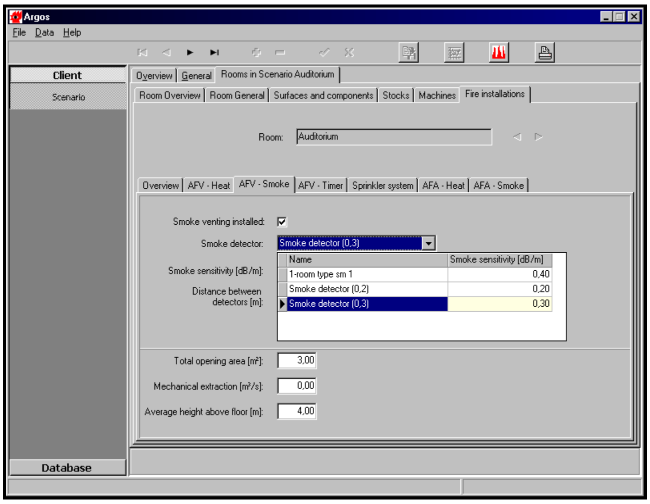


Figure 4.16: Select the smoke venting device on the AFV - Smoke tab.

Running the Scenario

We will use the same waste paper basket fire as in the previous scenario:

1. On the toolbar, click the **Simulate fire** button. The **Simulate fire** window opens. Click **Start**.

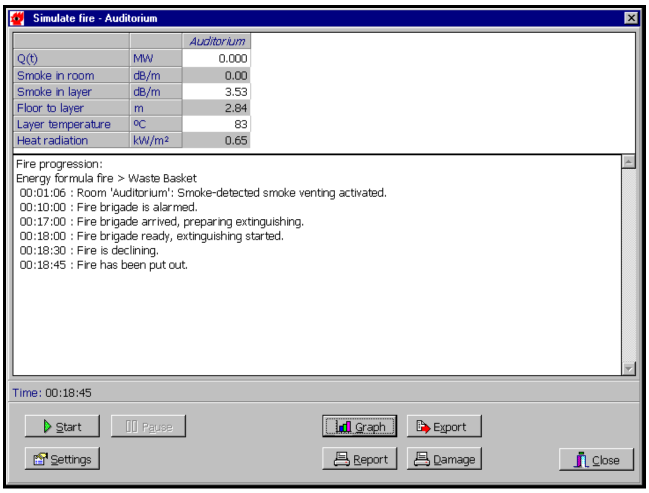


Figure 4.17: Launch the simulation in the Simulate fire window.

Interpreting the Results

The **Distance from floor to smoke layers** graph is particularly interesting. Note that the smoke layer does not go as low as in the previous scenario. This is of course due to the automatic venting device being activated after 1:06 minutes.

After 3 minutes, the height of the smoke layer stabilises at approximately 2.7 meters. This means that critical conditions do not arise at any point in the course of this fire.

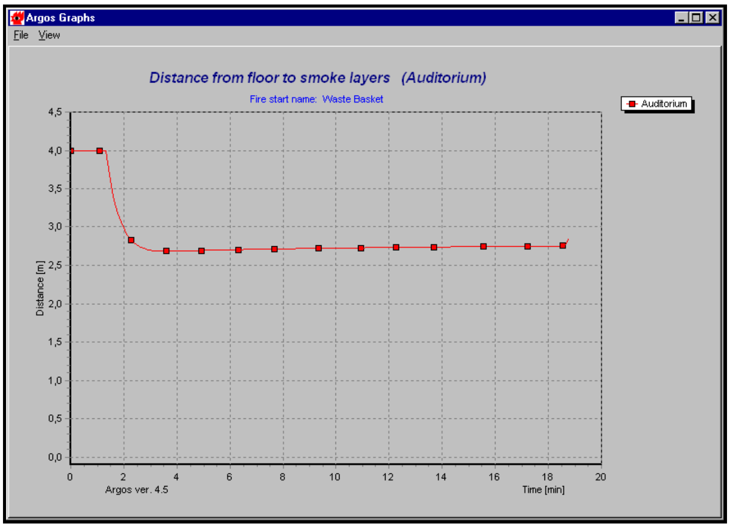


Figure 4.18: Distance from floor to smoke layers graph.

III The Auditorium — Sprinkler System Installed

In this scenario we re-use the information from the first scenario, only this time we install a sprinkler system. The objective is to analyse how the rate of heat release is influenced by sprinkler release.

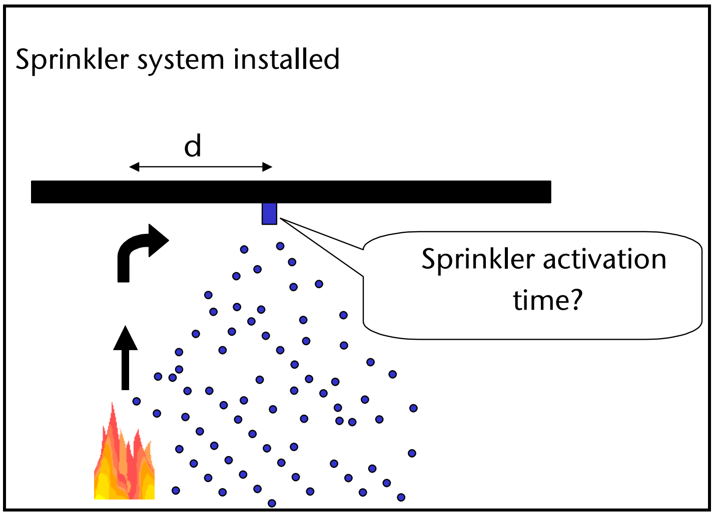


Figure 4.19: Scenario with sprinkler system installed.

Creating the Case Scenario

Since we have already created the Auditorium scenario, we simply need to update it with the information about the sprinkler system:

To add the sprinkler system:

1. Select the scenario in the Scenario pane, and go to the *Rooms in Scenario* tab.
2. Select the *Fire installations* tab.
3. On the *Sprinkler system* tab, type in the following information:

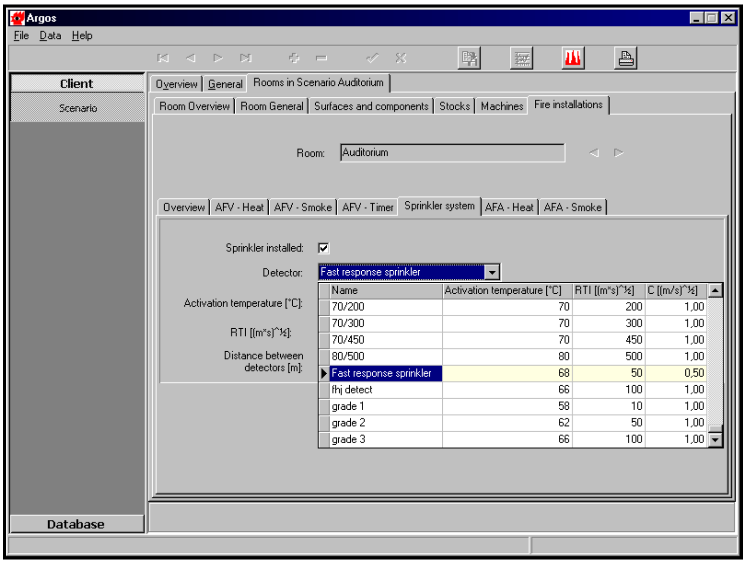


Figure 4.20: Select the sprinkler system on the Sprinkler system tab.

4. Click the **Save changes** button to save your changes.

Running the Scenario

1. On the toolbar, click the **Simulate fire** button to open the **Simulate fire** window.
2. Click **Settings** to open the **Simulation options** dialog box.
3. On the *Fire Installations/Wind load* tab, select the *Sprinkler system enabled in simulation* check box. Make sure to deactivate the remaining fire installations.
4. Click **OK** to save the changes.

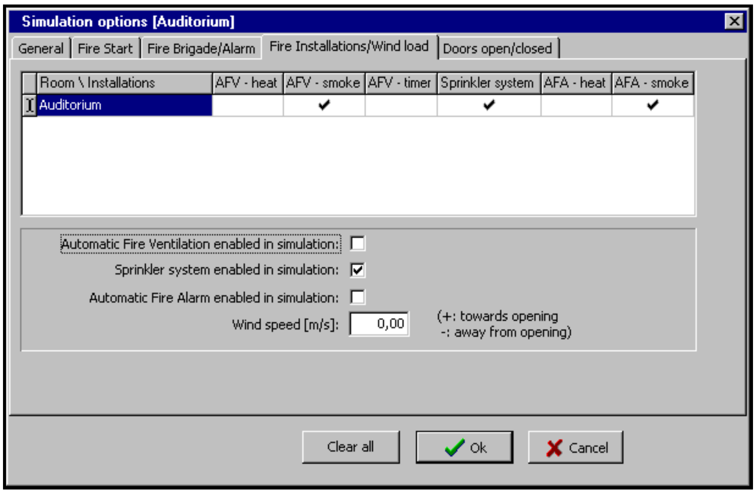


Figure 4.21: Activate the sprinkler system on the Fire Installations/Wind load tab in the Simulation options dialog box.

5. Back in the **Simulate fire** window, click **Start**.

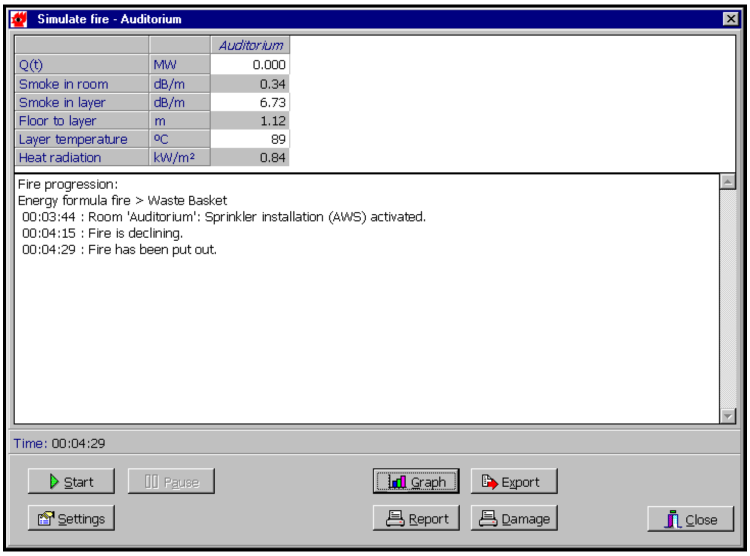


Figure 4.22: Launch the simulation in the Simulate fire window.

6. Note that the sprinkler is activated and released after 3:44 minutes and the fire is put out after 4:29 minutes.

Interpreting the Results

In this scenario, we will look at the **Rate of heat release from fire** and **Temperature in smoke layer** graphs.

Rate of heat release from fire

As can be seen from the graph below, the heat release reaches its maximum level of 0.5 after 1:07 minutes. This is identical to the previous scenario.

The sprinkler is released after 3:44 minutes and as a result the heat release starts decreasing after approximately 4:20 minutes. The fire is put out after 4:29 minutes.

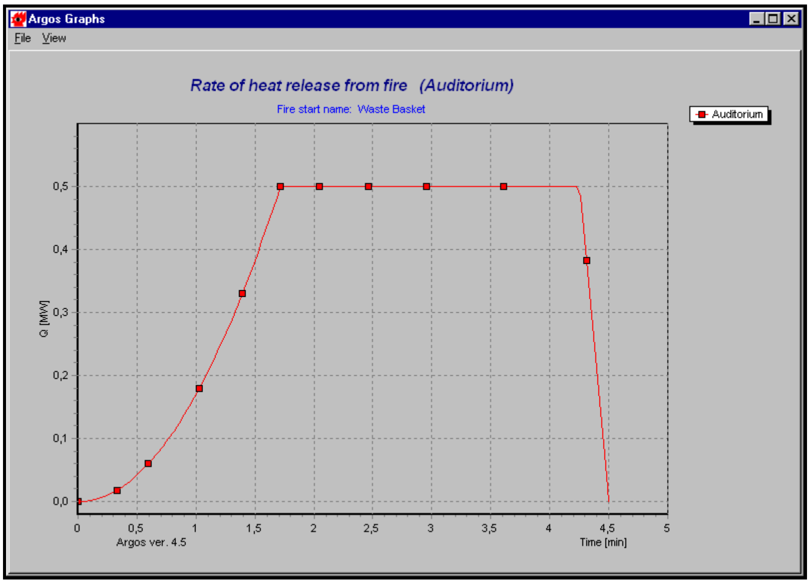


Figure 4.23: The Rate of heat release from fire graph.

Temperature in smoke layer

The **Temperature in smoke layer** graph shows the temperature in the smoke layer. The temperature falls after sprinkler release because of reduced heat release rate. In Argos, the sprinkler system does not cool the smoke layer.

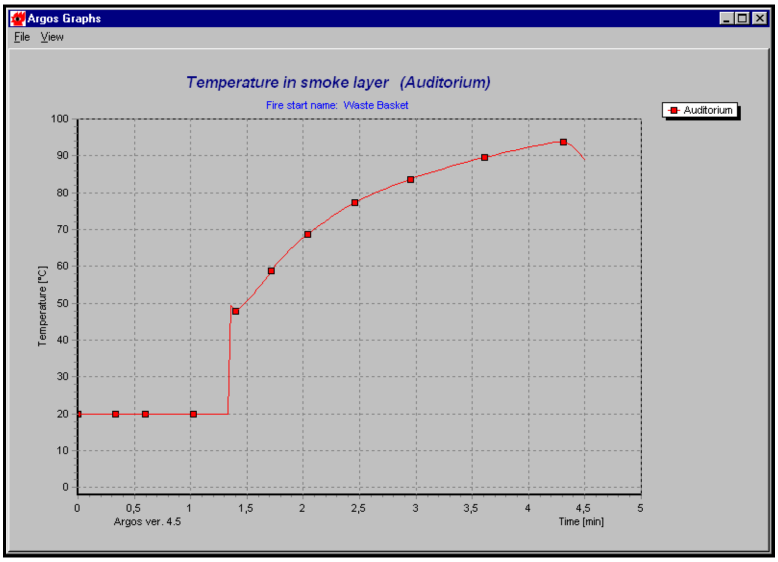


Figure 4.24: The Temperature in smoke layer graph.

IV The Auditorium — AFA Smoke Detector Installed

In this scenario, we will re-use the information from the Auditorium scenario, only this time we will install an automatic fire alarm.

The objective is to see how fast an automatic fire alarm equipped with a smoke detector will react to alarm the fire brigade. If the system were also coupled to a fire alarm sounder, occupants would be alerted at an early stage.

Creating the Case Scenario

Since we have already created the Auditorium scenario, we simply need to update it with information about the automatic fire alarm:

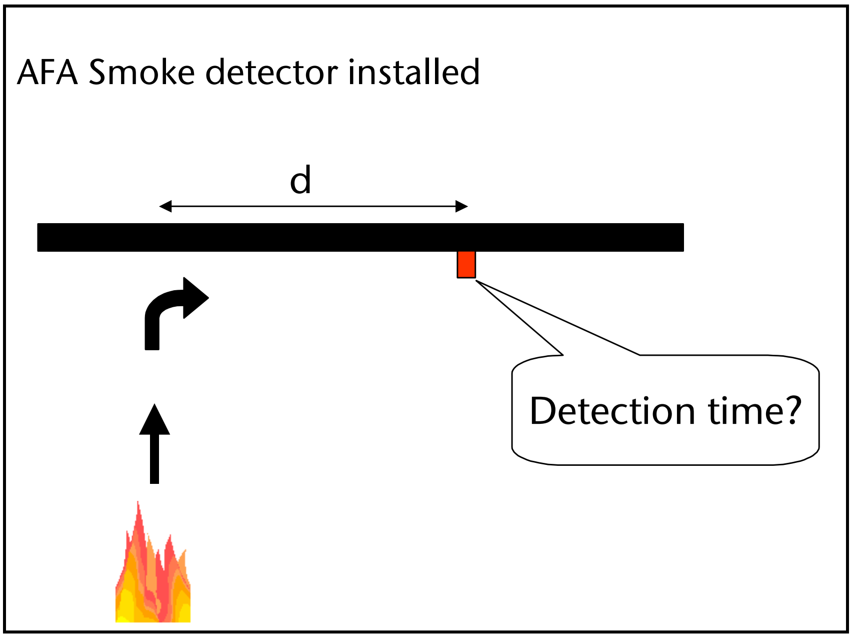


Figure 4.25: Scenario with AFA smoke detector installed.

To add the automatic fire alarm:

1. Select the scenario in the Scenario pane and go to the *Rooms in Scenario* tab.
2. Select the *Fire installations* tab.
3. On the *AFA - Smoke* tab, enter the type of smoke detector and the spacing between the detectors.

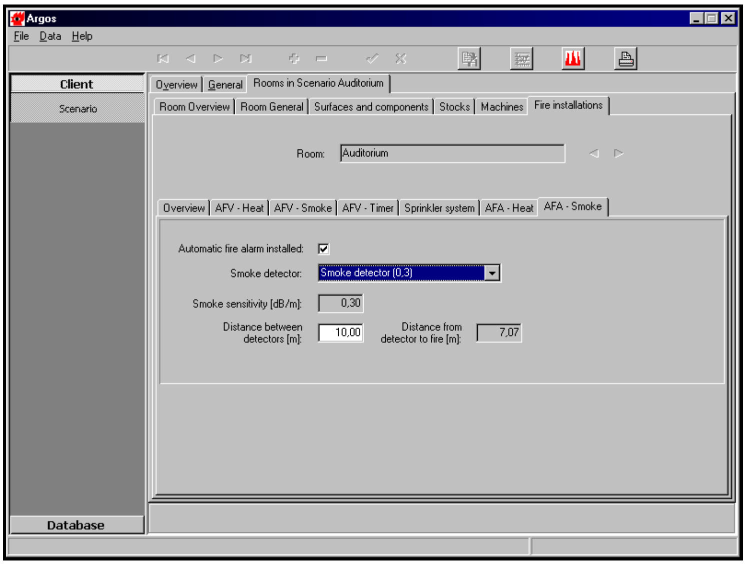


Figure 4.26: Select the AFA smoke detector on the AFA – Smoke tab.

4. Click the **Save changes** button to save your changes.

Running the Scenario

1. On the toolbar, click the **Simulate fire** button to open the **Simulate fire** window.
2. Click **Settings** to open the **Simulation options** dialog box.
3. On the *Fire Installations/Wind load* tab, select the *Automatic Fire Alarm enabled in simulation* check box. Make sure to deactivate the remaining fire installations.

4. Click **OK** to save the changes.

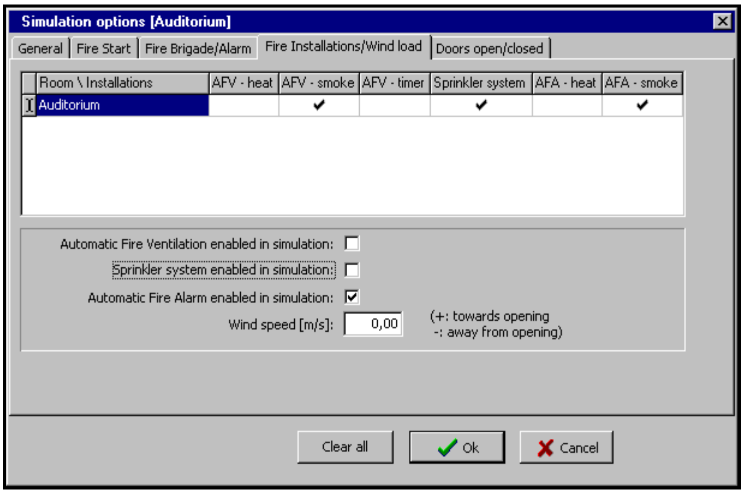


Figure 4.27: Activate the AFA smoke detector on the Fire Installations/Wind load tab in the Simulation options dialog box.

5. Back in the **Simulate fire** window, click **Start**.

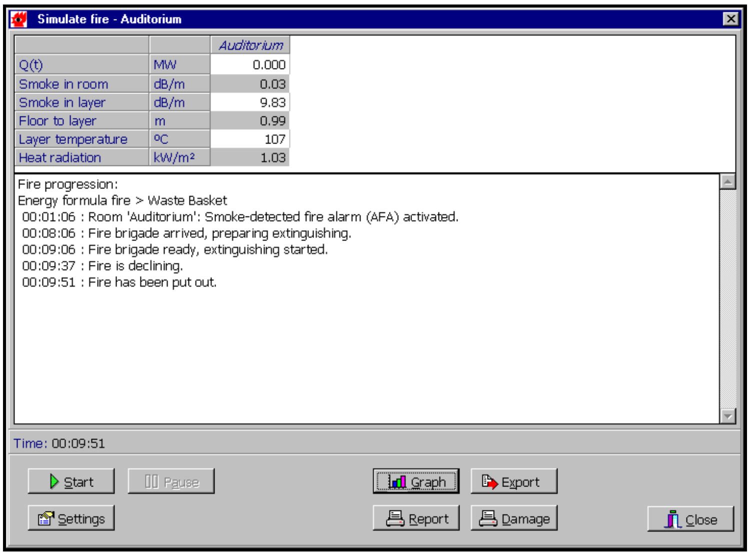


Figure 4.28: Launch the simulation in the Simulate fire window.

6. Note that the AFA is activated after 1:06 minutes. The fire brigade arrives after 8:06 minutes and the fire has been put out after 9:06 minutes.

Interpreting the Results

The **Rate of heat release from fire** graph shows that the AFA has had the intended impact. The fire is detected at an earlier stage which means that people can be evacuated earlier and that the fire brigade will arrive earlier on the scene.

The fire brigade arrives approximately 8 minutes earlier than they would have done without the alarm.

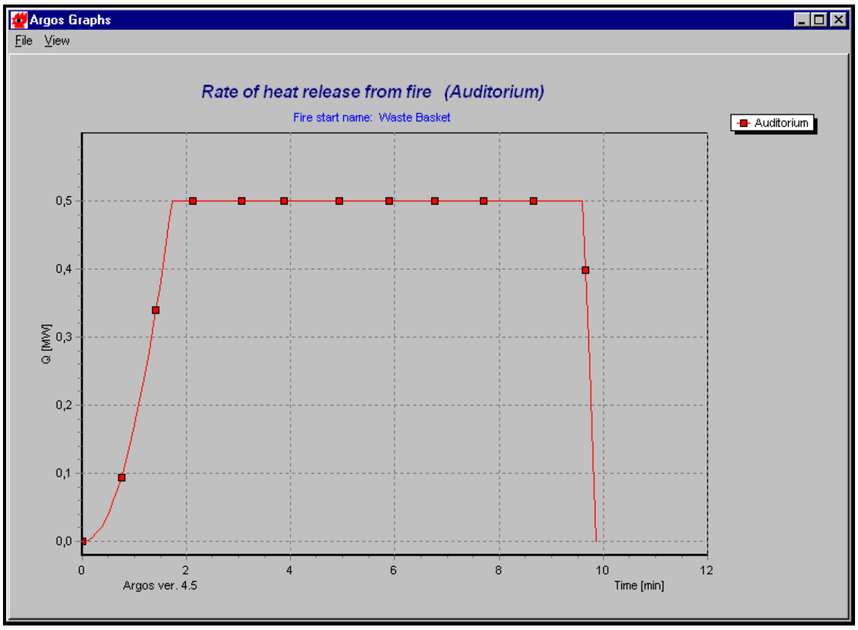


Figure 4.29: The Rate of heat release from fire graph.

V The Auditorium with Corridor

In this case scenario, we will first update the Auditorium with an additional room — a corridor. Then we will add an opening between the auditorium and the corridor.

The purpose is to show how to enter scenarios with more than one room into Argos. When interpreting the results, we will discuss how a fire will affect the surroundings outside the auditorium (in the corridor). This is of interest because the corridor may be used as an escape route in case of fire.

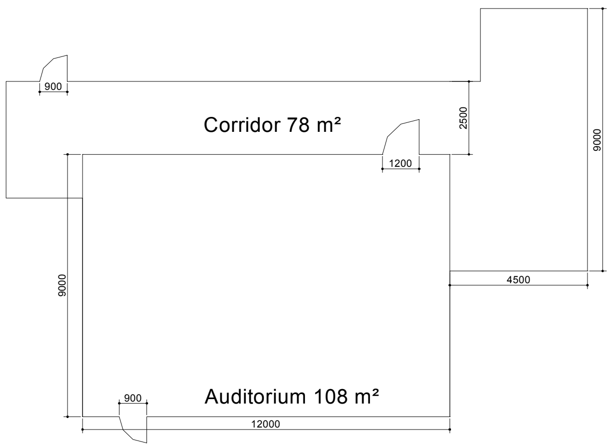


Figure 4.30: The Auditorium with corridor scenario.

Creating the Case Scenario

Load the Auditorium scenario and add the additional corridor:

1. Go to the *Room overview* tab and click the **Create** button. Add the area, average room height and max. distance for the corridor:

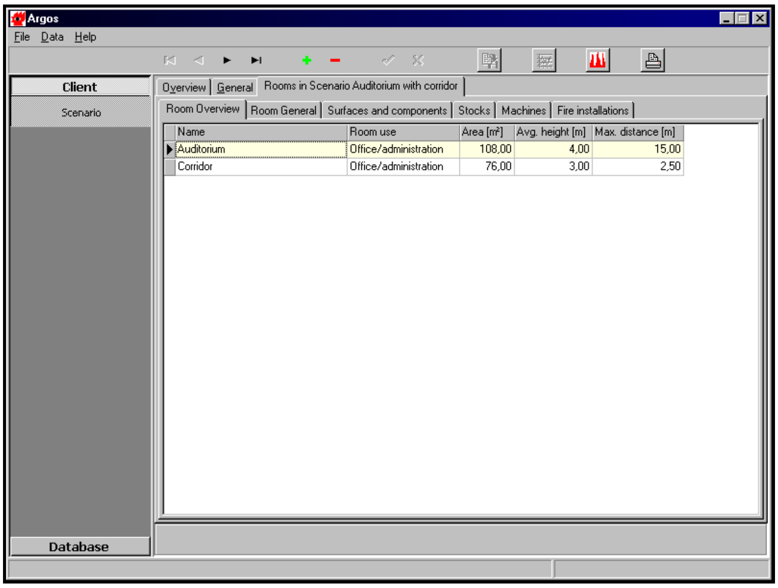


Figure 4.31: Add the corridor on the Room in Scenario tab.

2. Proceed to the *Surfaces and components* tab and type in the Corridor information on the *Walls* subtab. The two rooms are connected; the Auditorium to the Corridor, and the Corridor to the Surroundings.

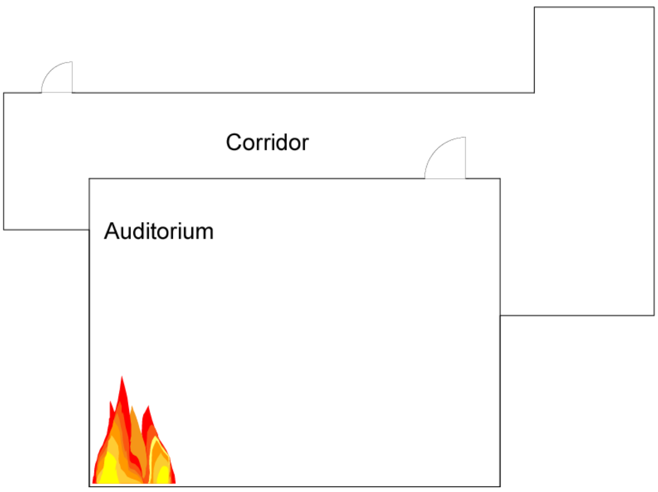


Figure 4.32: The fire starts in the auditorium.

Running the Scenario

Once all relevant information has been entered in Argos, we are ready to run the scenario:

1. On the toolbar, click the **Simulate fire** button to open the **Simulate fire** window.
2. Click **Settings** to open the **Simulation options** dialog box.
3. On the *Fire Start* tab, indicate that the fire should start in the *Auditorium*.
4. Select the *Waste paper Basket* fire again.

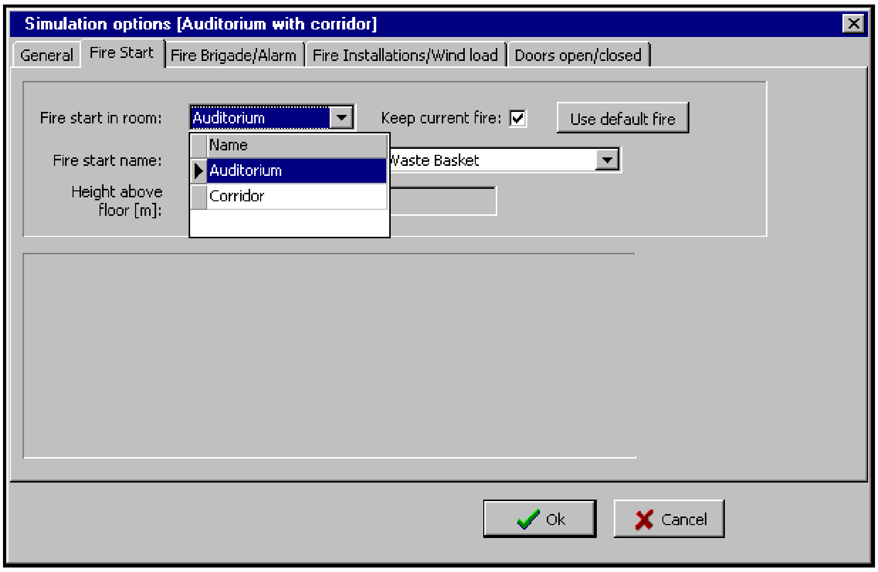


Figure 4.33: Use the Fire Start tab in the Simulation options dialog box to indicate that the fire starts in the auditorium.

7. Proceed to the *Fire Installations/Wind load* tab and deselect fire installations.

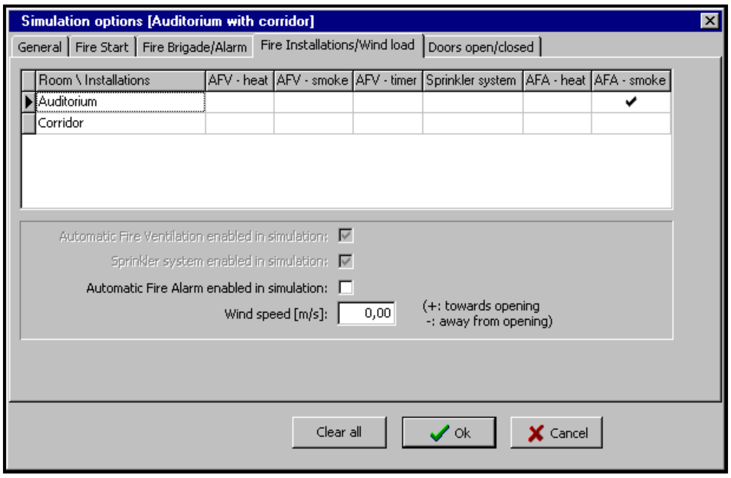


Figure 4.34: Deselect fire installations on the Fire Installations/Wind load tab.

8. On the *Doors open/closed* tab, make sure that the solid wood door in the Auditorium is closed. The steel door between the Auditorium and the Corridor, as well as the solid wood door between the corridor and the surroundings, should be open.

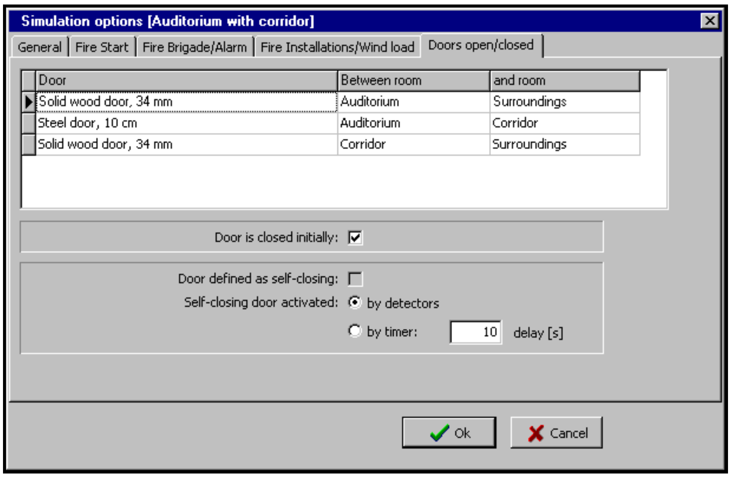


Figure 4.35: Indicate door positions on the Doors open/closed tab.

9. Click **OK** to save the changes.

10. Back in the **Simulate fire** window, click **Start** to run the scenario.

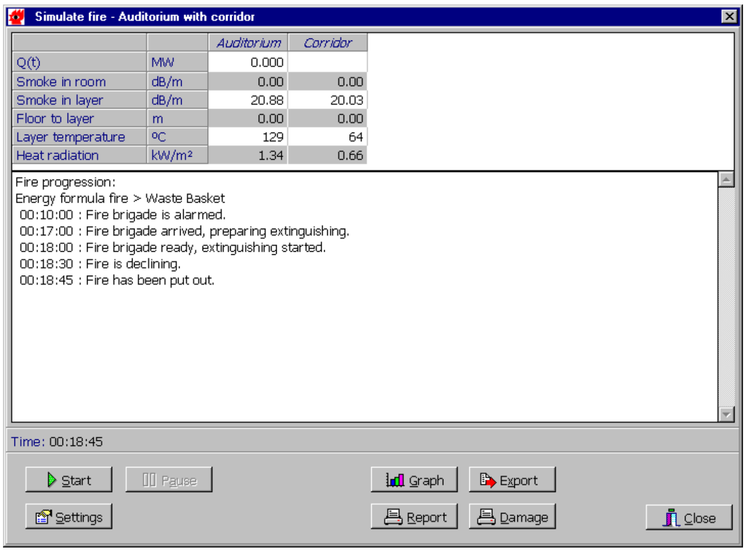


Figure 4.36: Launch the scenario in the Simulate fire window.

Interpreting the Results

The **Distance from floor to smoke layers** graph shows that the smoke layer is first formed in the Auditorium. When the height of the smoke layer drops below 2.10 meters, which is the height of the door between the Auditorium and the corridor, the smoke enters the corridor.

After a short time, a smoke layer is formed in the corridor.

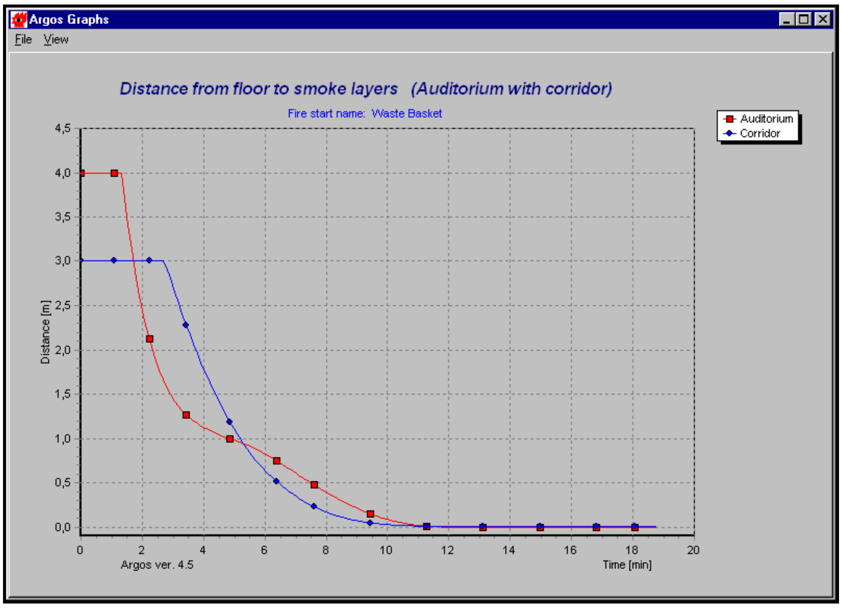


Figure 4.37: The Distance from floor to smoke layers graph.

VI The Auditorium with Corridor – Self-Closing Doors

In this scenario, we will see how the deployment of a self-closing door influences the conditions in the auditorium and in the corridor.

Figure 4.38: A self-closing door.

Creating the Case Scenario

Since we have already created the Auditorium with corridor scenario, we simply need to update it with the information about the self-closing door.

To add the self-closing door:

1. Load the Auditorium with corridor scenario and go to the *Components and surfaces* tab.
2. Select the *Walls* subtab. In the *Components in selected wall* section, select the *Self-closing door* option.
3. Click the **Save changes** button to save your changes.

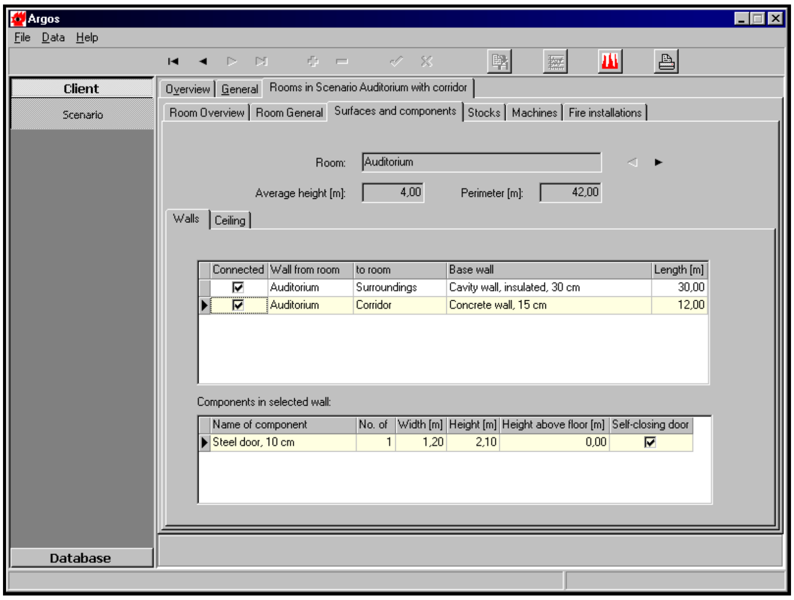


Figure 4.39: Select the Self-closing door option in the Components in selected wall section.

Running the Scenario

Before running the scenario, you need to activate the automatic fire alarm (AFA). In this scenario, it is the automatic fire alarm that triggers the self-closing door but it may also be closed by a timer.

1. On the toolbar, click the **Simulate fire** button to open the **Simulate fire** window.
2. Click **Settings** to open the **Simulation options** dialog box.
3. On the *Fire Installations/Wind load* tab, select the *Automatic Fire Alarm enabled in simulation* check box.
4. Click **OK** to save your changes.

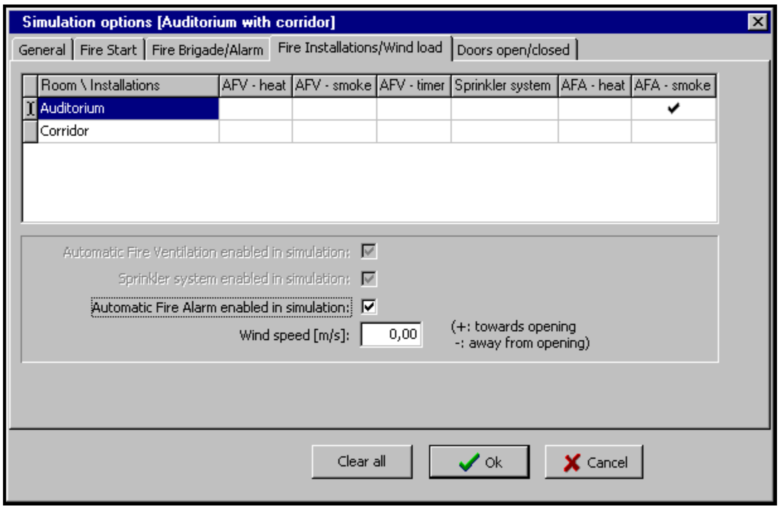


Figure 4.40: On the Fire Installations/Wind load tab, *Activate the automatic fire alarm (AFA). It is the automatic fire alarm that triggers the self-closing door.*

5. Back in the **Simulate fire** window, click **Start** to run the scenario.

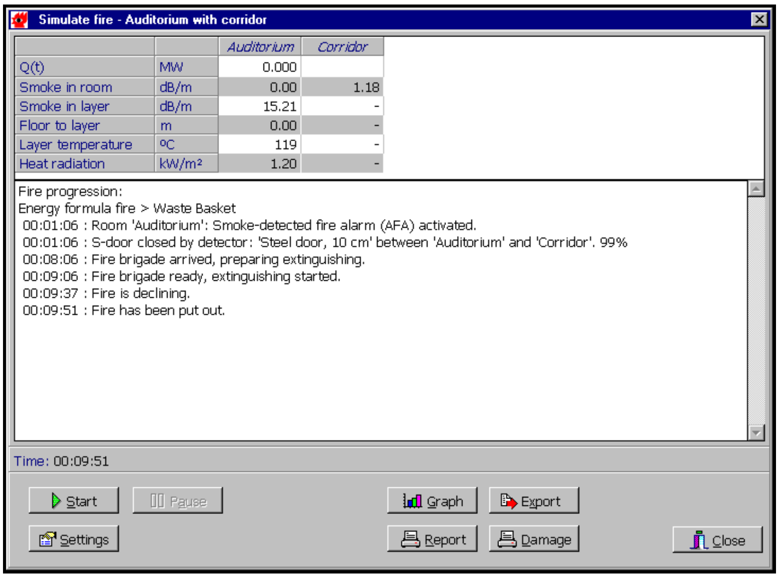


Figure 4.41: Launch the simulation in the Simulate fire window.

6. Note that the automatic fire alarm is activated after 1:06 minutes and that the self-closing door starts closing at the same time.

Interpreting the Results

As shown in the **Distance from floor to smoke layers** graph below, there is no smoke in the corridor, which was the main purpose of installing a self-closing door.

In the auditorium, critical conditions occur after 1½ minutes.

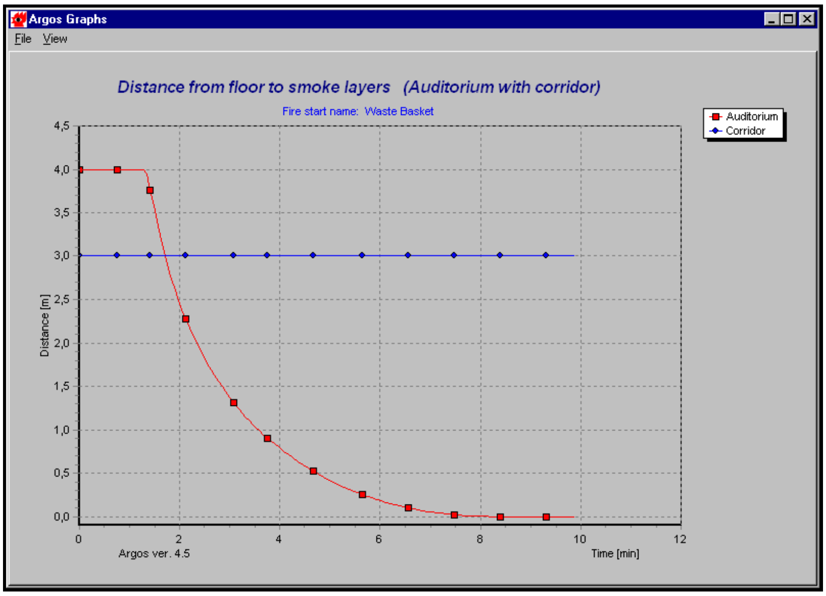


Figure 4.42: The Distance from floor to smoke layers graph.

VII The Sports Arena

A client wants to use Argos for assessing the fire safety and life safety conditions in a sports arena. The arena, which has already been built, is primarily used for sporting events such as football.

The following physical and geometry information is available:

- The sports arena is constructed as one single fire compartment.
- The supporting construction is unprotected steel lattice girders.
- The main area is 76.2 m x 108 m = 8230 m^2.
- The roof is dome-shaped with a maximum height of 12.1 meters going from the lower side of the steel lattice girders to the floor.

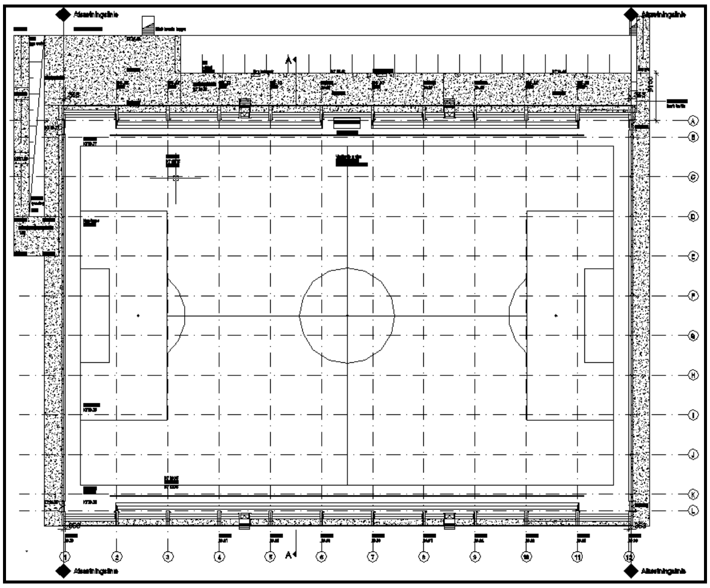


Figure 4.43: The sports arena seen from above.

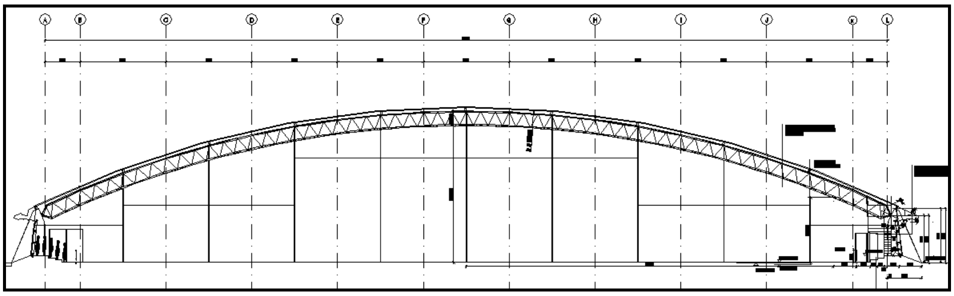


Figure 4.44: Cross section of the sports arena.

In order to create a simulation in Argos, approximately half of the area is divided into five fictive cubes. These cubes are interconnected by openings. This model is on the safe side because the volume in which the smoke can develop is less than in real life. The sketch of the model is shown in the figure below:

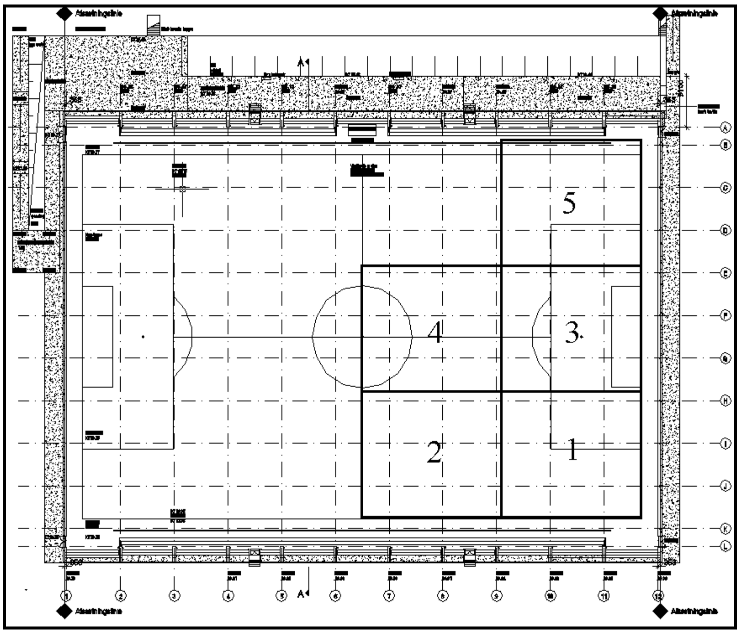


Figure 4.45: Half of the area is divided into five fictive cubes.

The geometry of the five cubes is as follows:

Description	Width (m)	Depth (m)	Height (m)	Max Distance
Room 1	25.4	27.0	8.0	18.5
Room 2	25.4	27.0	8.0	18.5
Room 3	25.4	27.0	10.7	18.5
Room 4	25.4	27.0	10.7	18.5
Room 5	25.4	27.0	8.0	18.5

Creating the Case Scenario

The first step is to create a new scenario in Argos:

1. Click the **Create** button, go to the *General* tab and enter the following information:

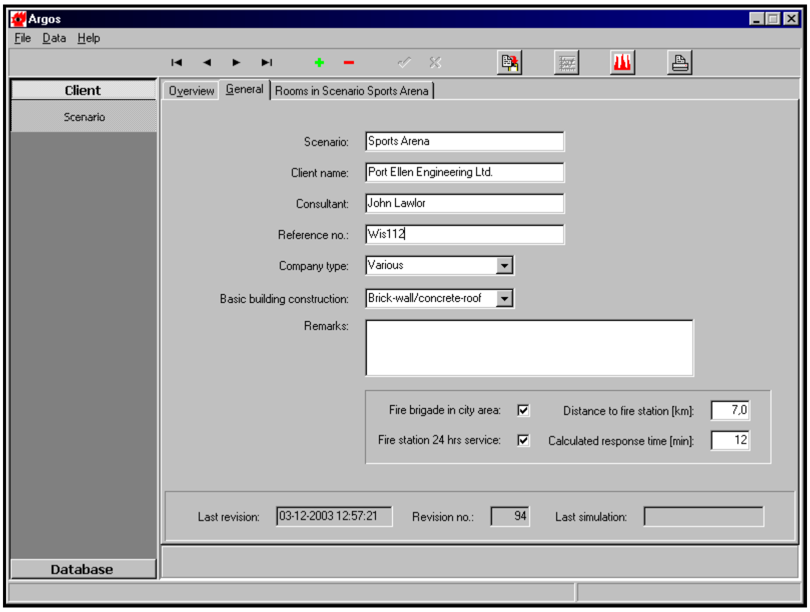


Figure 4.46: The General tab.

2. Click the **Save changes** button. Go to the *Rooms in Scenario Sports Arena* tab.

3. On the *Room Overview* subtab, enter the basic physical information of each room.

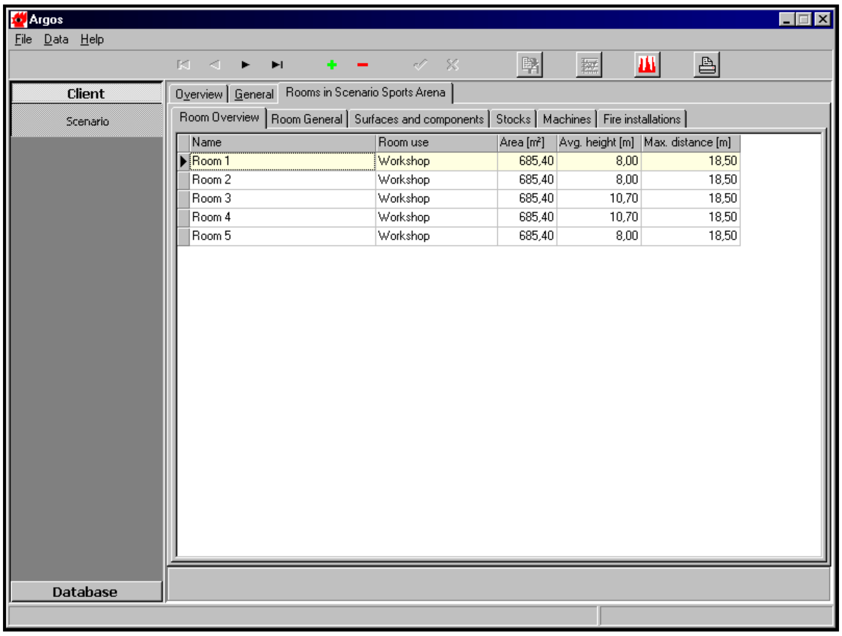


Figure 4.47: Define each of the rooms on the Rooms in Scenario tab.

6. Select the *Surfaces and components* tab. On the *Walls* subtab, enter information about the walls in each room. Use the *Connected* check box to indicate that rooms are connected with each other via doors or openings. Don't forget to indicate the length of each wall. (Note that the type of wall between the virtual cells is not important, since most of the wall is, in effect, an opening. In this case, we have chosen a steel wall.)

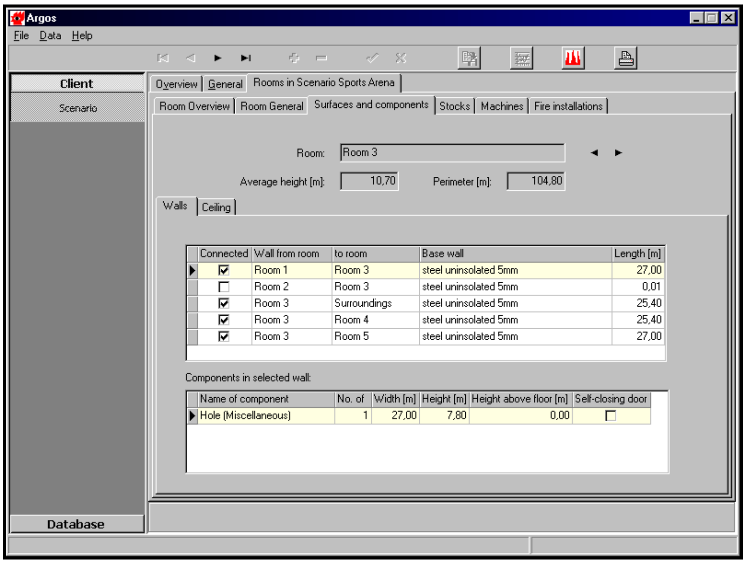


Figure 4.48: On the Walls subtab, enter information about the walls in each room.

7. Proceed to the *Ceilings* subtab to enter information about the ceiling in each room.

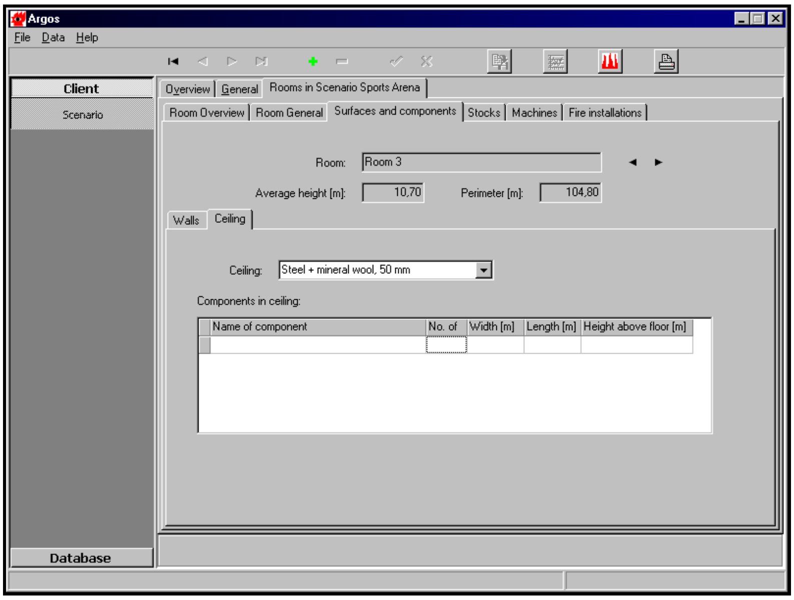


Figure 4.49: On the Ceiling subtab, enter information about the walls in each room.

8. On the *Stocks* tab, delete all stock entries for all rooms. This information is not relevant for this scenario.

9. On the *Machines* tab, delete all machine entries for all rooms. This information is not relevant for this scenario.

4. Click **Post entries** to save the case scenario.

Running the Scenario

1. Once all relevant information has been entered in Argos, you are ready to run the scenario.

2. On the toolbar, click the **Simulate fire** button to open the **Simulate fire** window.

3. First you must select a fire. Click **Settings** to open the **Simulation options** dialog box. The fire must start in Room 1. Enter information about where the fire starts, the type of fire and the name of the fire.

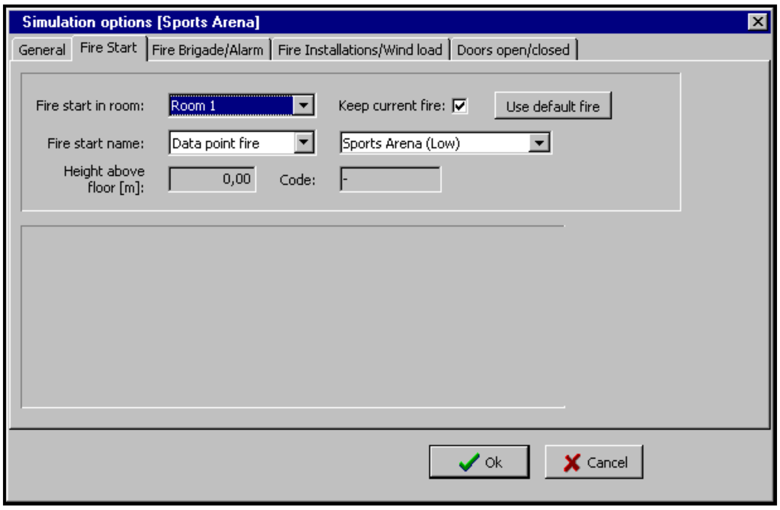


Figure 4.50: Select the initial fire on the Fire Start tab in the Simulation options dialog box.

4. Click **OK** to save your changes.

5. Back in the **Simulate fire** window, click **Start** to run the scenario.

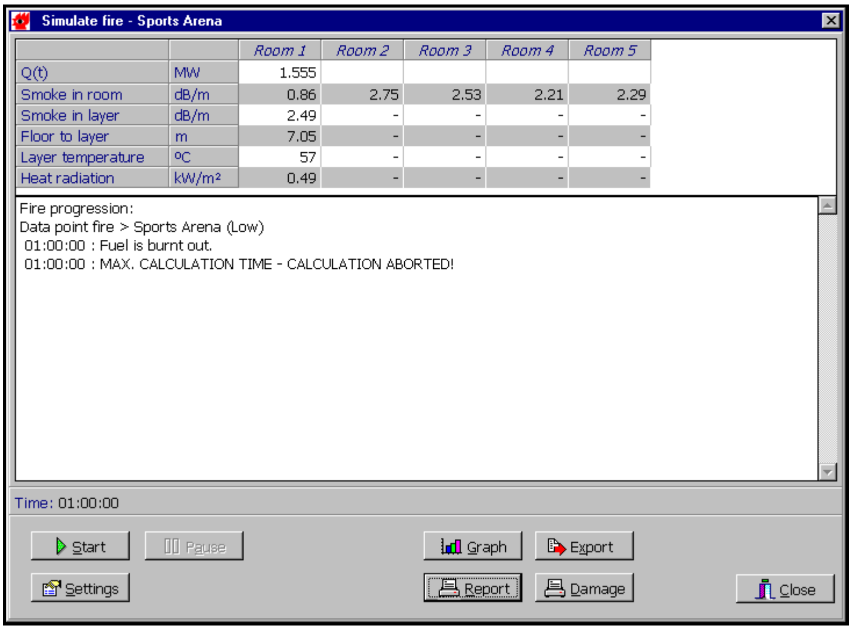


Figure 4.51: Launch the scenario in the Simulate fire window.

Interpreting the Results

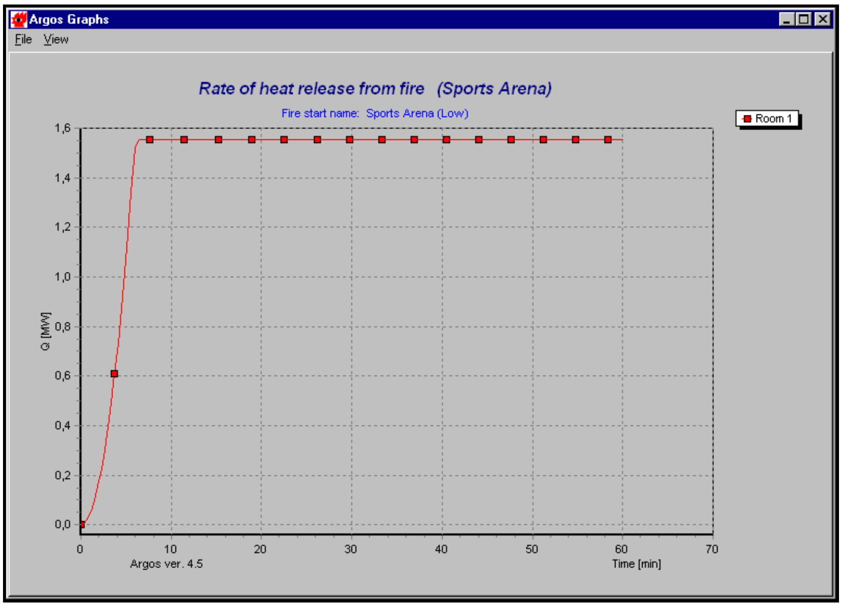


Figure 4.52: The Rate of heat release from fire graph.

The **Rate of heat release from fire** graph clearly shows that the heat release is stabilized after approximately 7 minutes. At this point, no more combustible material is involved in the fire than that material which is currently burning.

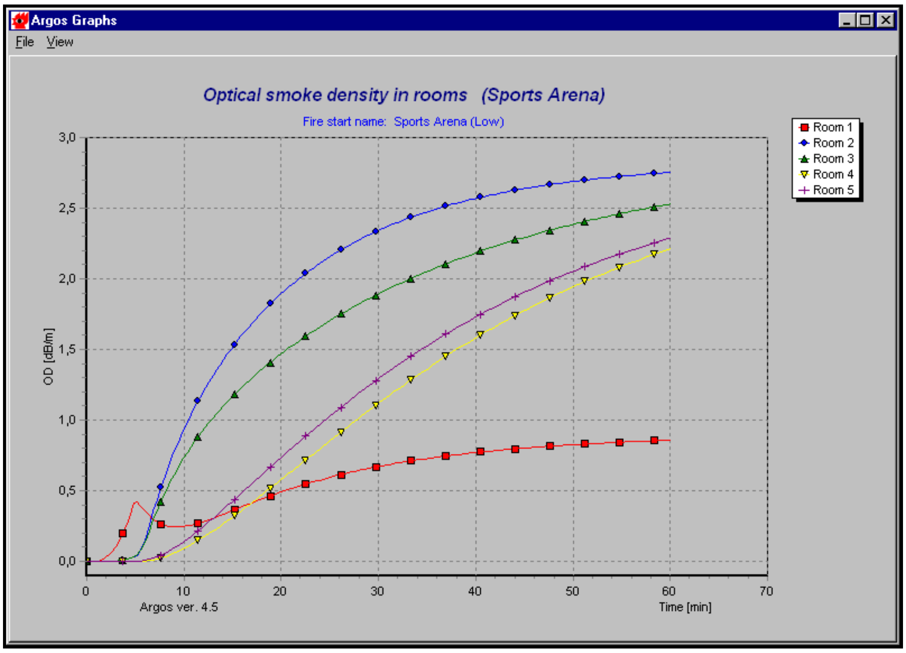


Figure 4.53: The Optical smoke density in rooms graph.

The **Optical smoke density in rooms** graph shows critical conditions do not occur at any point in Room 1. In the other rooms, however, we do find critical conditions for the people there as the level surpasses 1.0 OD [dB/m]. This happens:

- in Room 2 after 10 minutes
- in Room 3 after 12 minutes
- in Room 4 after 27 minutes
- in Room 5 after 24 minutes

Note that the optical density in the fire room is less than in the other rooms. This is because a 2-zone model is generated in the fire room, whereas a 1-zone model with cold smoke is generated in the remaining rooms.

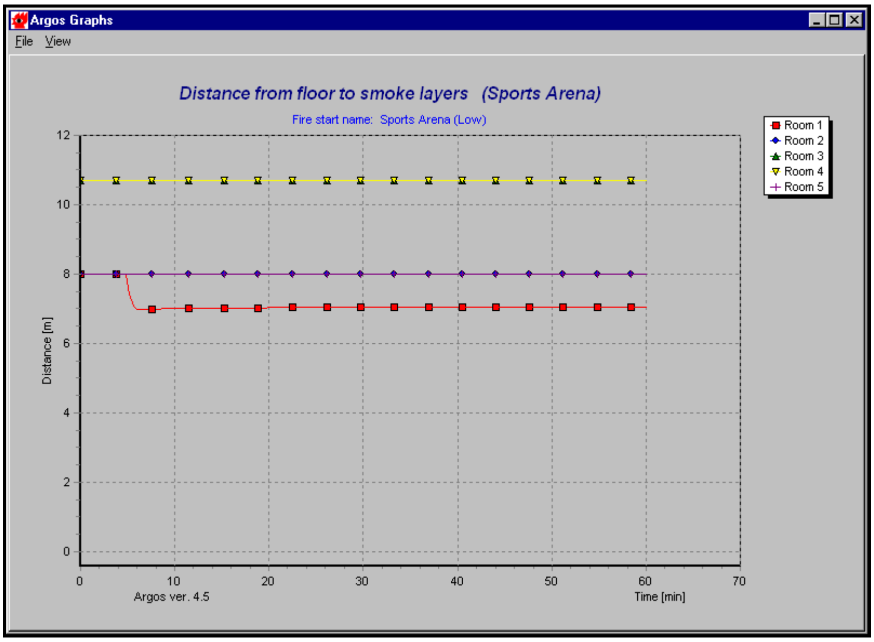


Figure 4.54: The Distance from floor to smoke layers graph.

The **Distance from floor to smoke layers** graph shows that a smoke layer is only formed in Room 1. At no point do we find critical conditions in any of the rooms.

We also see that there is a smoke layer in Room 1, where the fire is located.

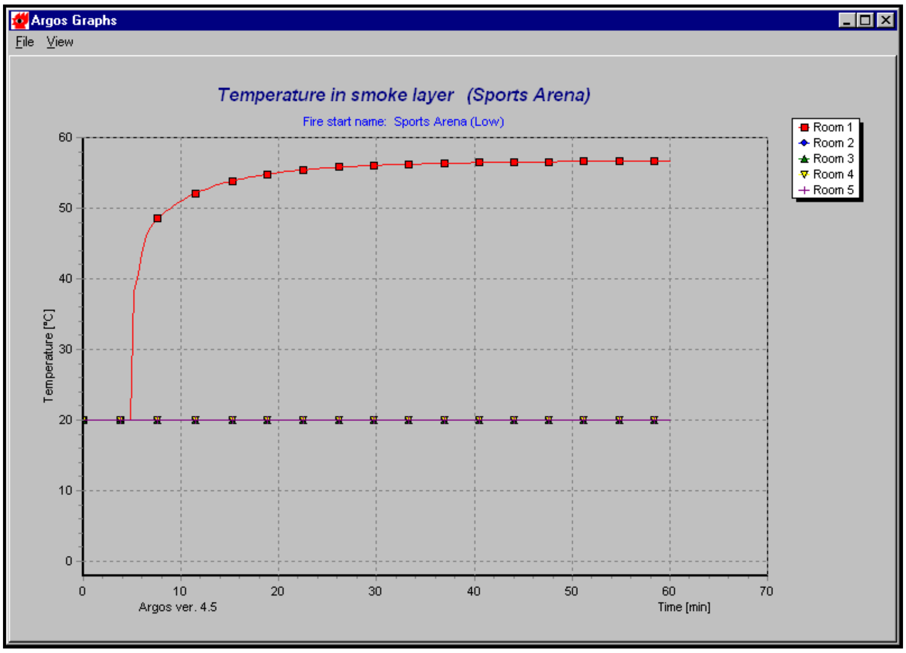


Figure 4.55: The Temperature in smoke layer graph.

The **Temperature in smoke layer** graph shows a temperature in Room 1, which is not critical.

We can also see that the supporting unprotected steel will be heated by less than 40°C, which means that the steel structure will retain its full load-bearing capacity.

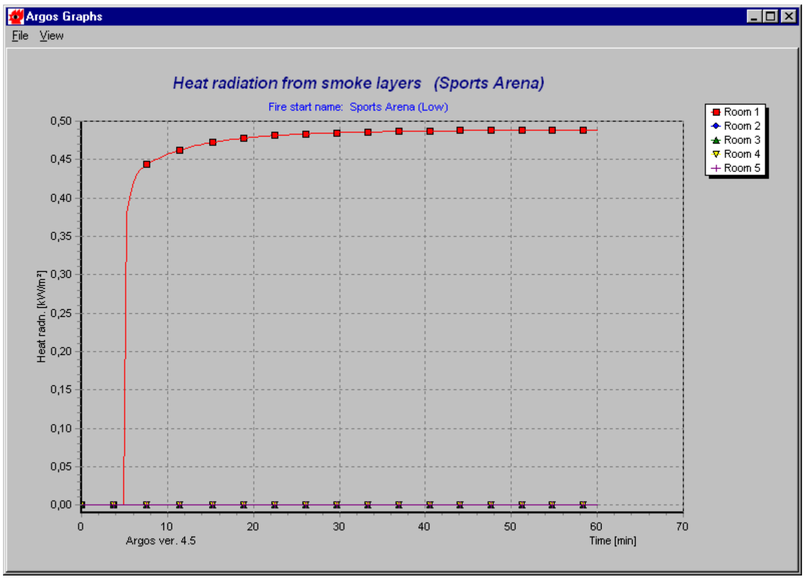


Figure 4.56: The Heat radiation from smoke layers graph.

The **Heat radiation from smoke layers** graph shows that the heat radiation from the smoke layers at no point is critical. The heat radiation is less than 2.5 kW/m^2.

VIII The Auditorium with Flash-over

In this scenario, we will extend the Auditorium scenario to a post-flash-over fire. In order to do so we need to choose a powerful fire and instruct Argos to continue analysing after the flash-over.

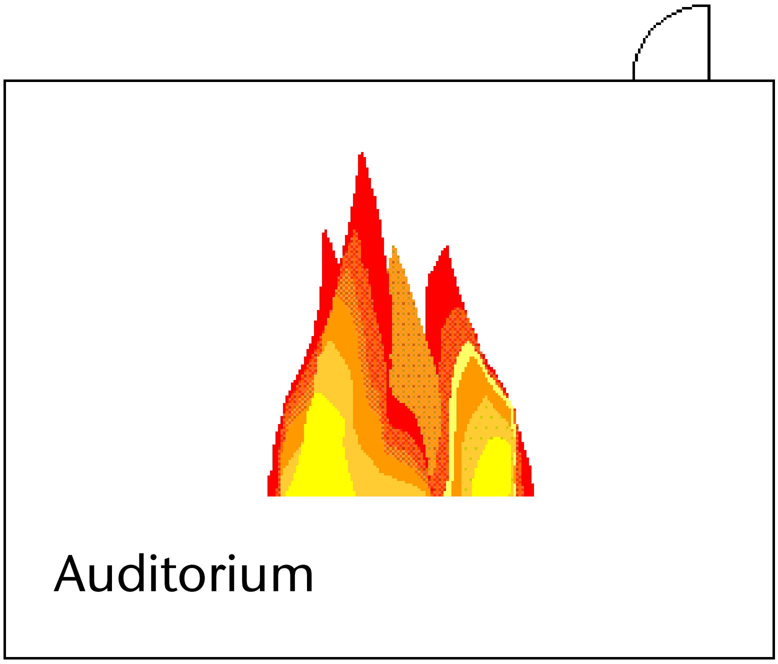


Figure 4.57: Flash-over in the auditorium.

Running the Scenario

1. Load the Auditorium scenario and click the **Simulate fire** button to open the **Simulate fire** window.
2. Click **Settings** to open the **Simulate Options** dialog box.
3. On the *General* tab, make sure that the *Enable post flash-over model* check box is selected.

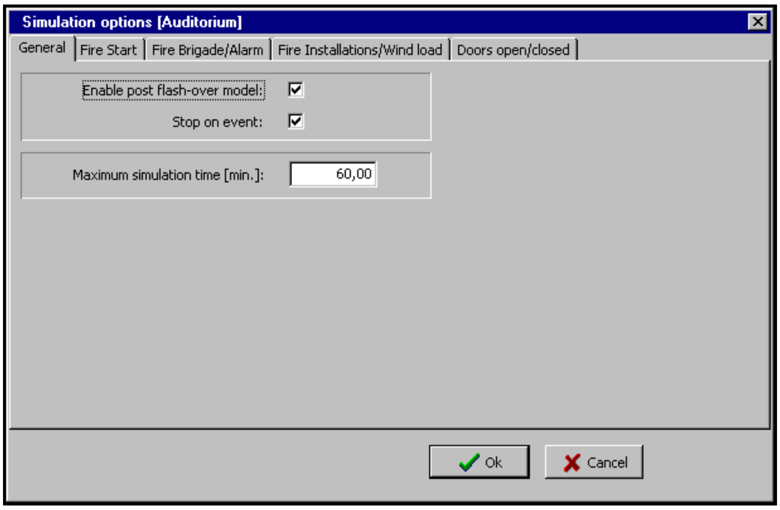


Figure 4.58: Select the Enable post flash-over model check box.

4. On the *Fire Start* tab, select the *Ultra Fast* fire option in the *Fire start name* drop-down list box.

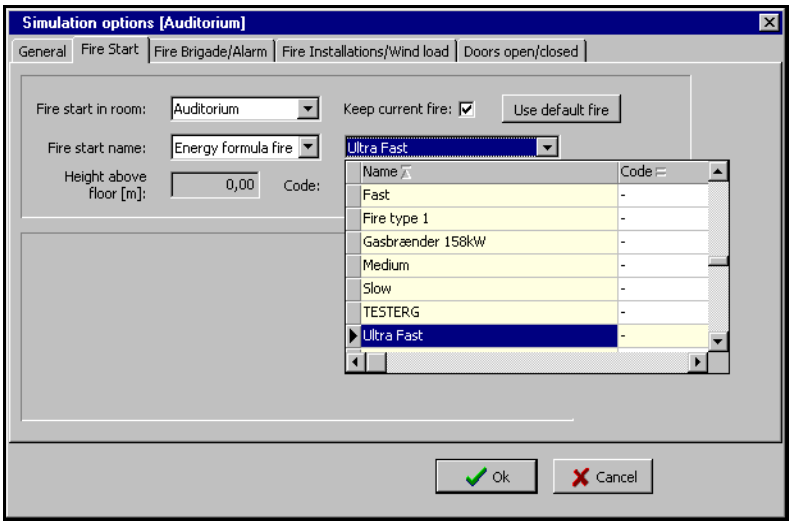


Figure 4.59: Select a powerful initial fire such as the Ultra Fast energy formula fire.

5. On the *Fire Installations/Wind speed* tab, deactivate any fire installations.

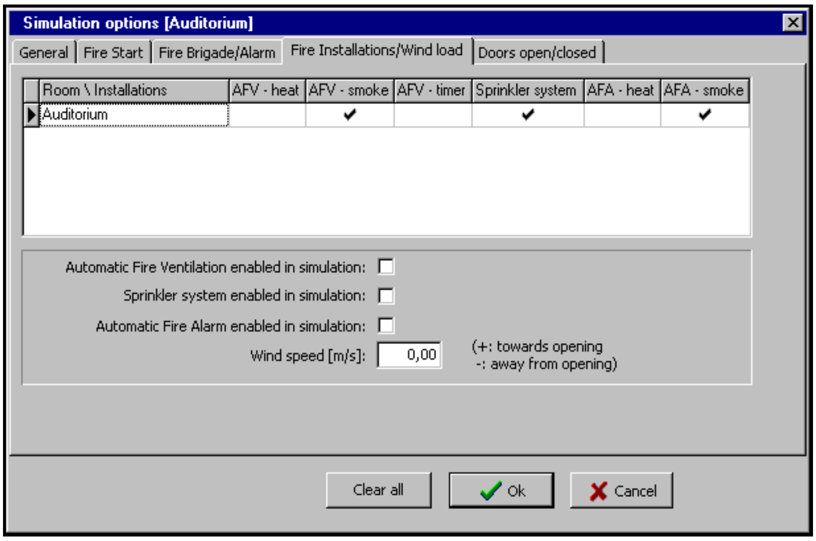


Figure 4.60: Deactivate any fire installations.

6. Click **OK** to save your changes.

7. Back in the **Simulate fire** window, click **Start** to run the scenario.

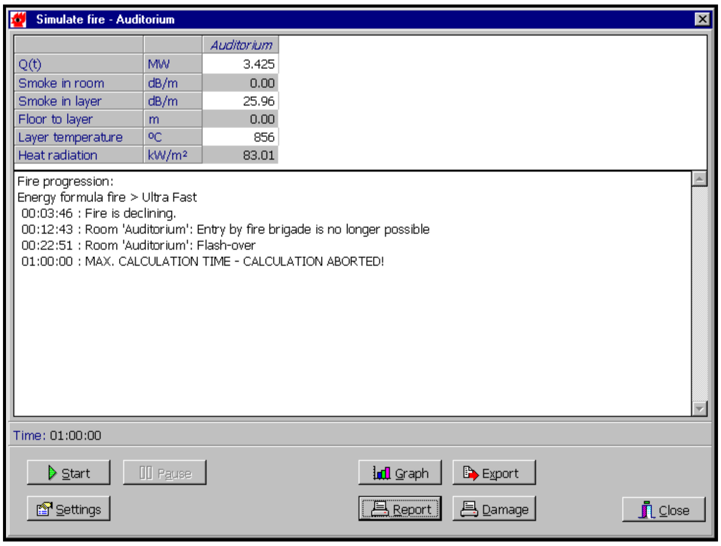


Figure 4.61: Launch the scenario in the Simulate fire window.

Interpreting the Results

In this scenario, we will look at the following graphs:

- Rate of Heat release from fire
- Optical smoke density in rooms
- Optical smoke density in smoke layers
- Distance from floor to smoke layers

As shown in the **Rate of heat release from fire** graph below, the fire goes from being fuel-controlled to ventilation-controlled after 3-4 minutes.

After approximately 22 minutes, we notice a decrease in the rate of heat release value, indicating the occurrence of flash-over.

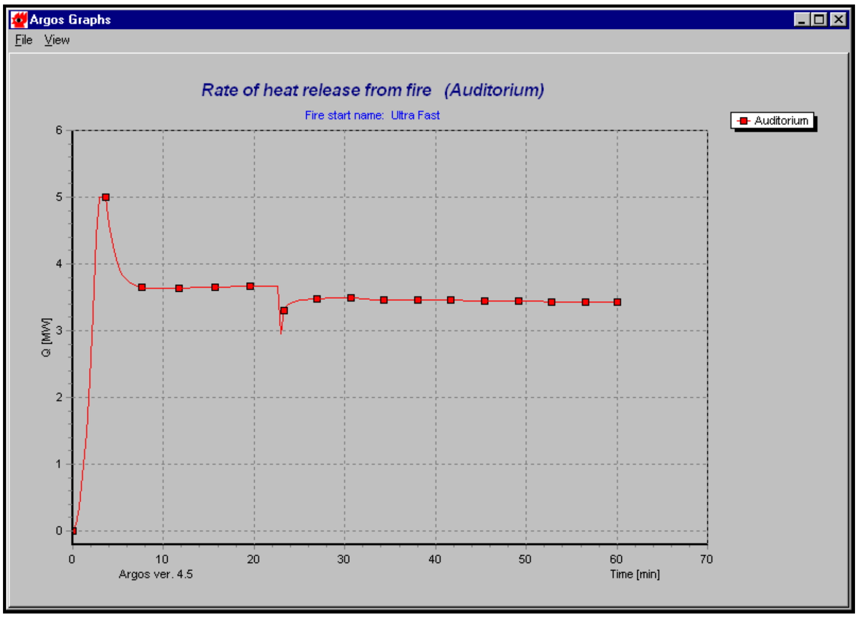


Figure 4.62: The Rate of heat release from fire graph.

The **Optical smoke density in rooms** graph below shows that a smoke layer is generated early in the model because of the size of the fire. But after 2 minutes, the density goes to zero because the smoke layer reaches the floor.

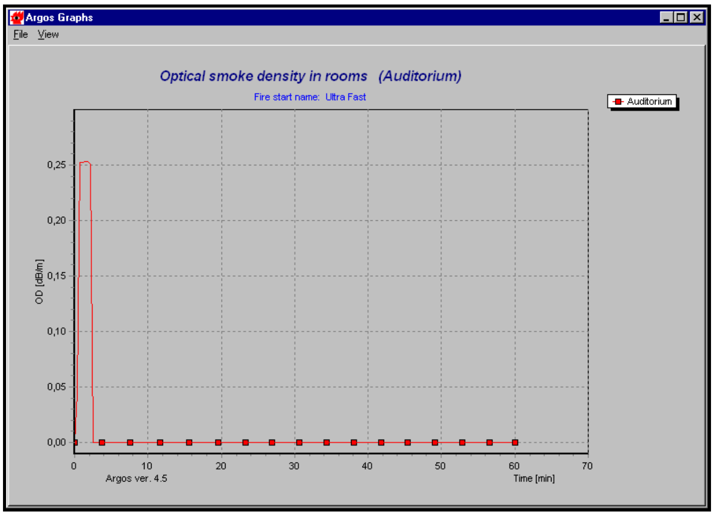


Figure 4.63: The Optical smoke density in rooms graph.

The **Optical smoke density in smoke layers** graph below shows that after 1 minute the visibility in the smoke layer is very low.

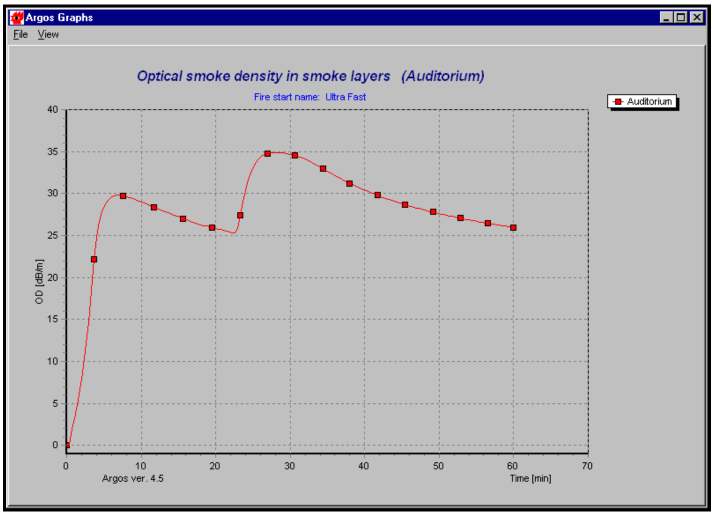


Figure 4.63: The Optical smoke density in smoke layers graph.

The **Distance from floor to smoke layers** graph below shows that the room is quickly filled with smoke.

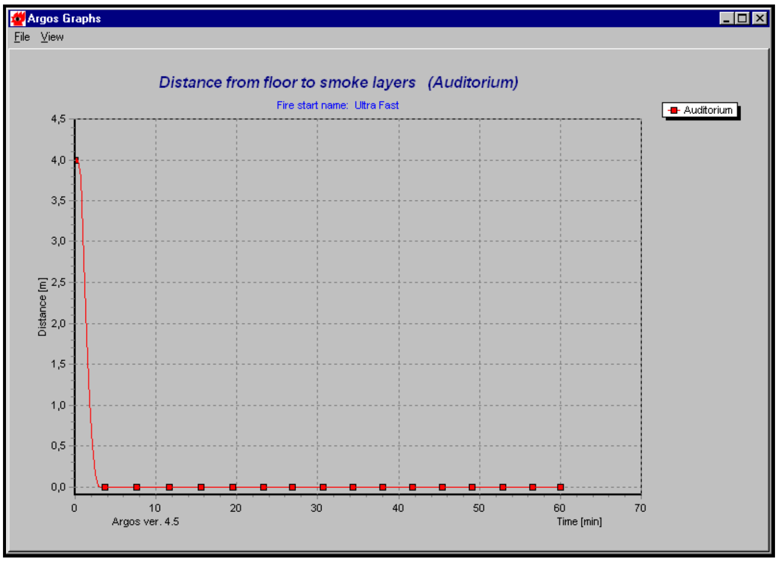


Figure 4.65: The Distance from floor to smoke layers graph.

Chapter 5: Graphs in Argos

This chapter provides a detailed description of the graphs generated by Argos during a simulation. When a scenario is calculated, Argos will generate 15 graphs showing relevant information that will help you in your conclusion-making. The information displayed includes the following:

- The rate of heat release from fire
- The optical smoke density in rooms and in smoke layers
- The distance from floor to smoke layers
- The temperature in smoke layers
- The heat radiation from smoke layers
- The heat loss through surfaces
- The oxygen levels in rooms and in layers
- Lower and upper ceiling surfaces
- The ceiling temperature profile
- The average temperature
- Floor Pressure
- Numerical Integration Step Length

Rate of heat release from fire

This graph shows the rate of heat release from the fire as seen over time. The graph expresses the speed with which the fire grows and how big it becomes.

The rate of the heat release from a fire is a major indication of the threat from the fire to life and property. Increase in the heat release rate will increase heat and smoke production, which will worsen the escape conditions.

The following factors will have impact on the heat release rate in Argos: The type of fire used for the simulation; the nature of openings (ingress of fresh air); and sprinklers.

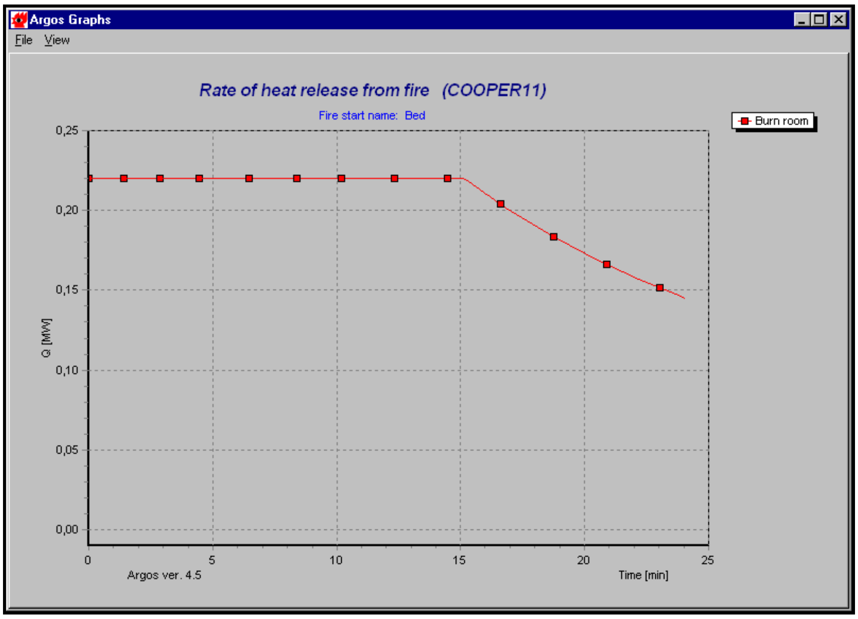


Figure 5.1: The Rate of heat release from fire graph.

Optical smoke density in rooms

This graph shows the density of the smoke in the room, before the smoke layer is formed. In this period, all smoke spreads evenly in a room and the smoke density is the same everywhere. When a smoke layer is formed in a room, optical smoke density in rooms refers to the volume below the smoke layer. The cold smoke, which is generated before the smoke layer is formed, is located below the smoke layer.

The optical density (OD) is measured in dB/m. An optical density of zero means that there is unlimited visibility. An optical density of 1 db/m equals a visibility of 10 m. An optical density of 2 dB/m equals a visibility of 5 m.

The formula for visibility in meters in rooms is *Visibility = 10/OD*

The graph tells us at what point in time critical conditions can occur. If the visibility figure is below 10 meters in larger rooms and 3-5 meters in smaller rooms you have what are considered as critical conditions. Factors such as the size of the fire and the amount of smoke generated by the burning materials will influence smoke density. For instance, burning diesel oil will generate more smoke than burning wood.

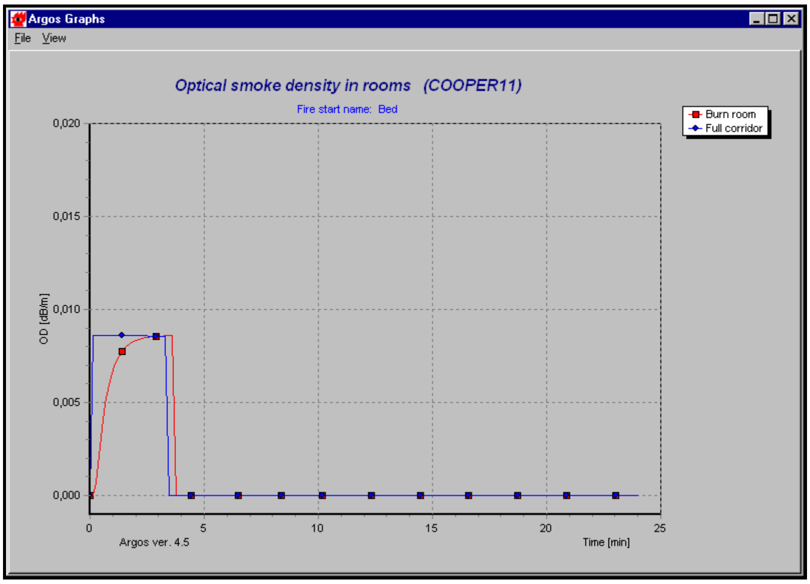


Figure 5.2: The Optical smoke density in rooms graph.

Optical smoke density in smoke layers

This graph shows the density of the smoke in the smoke layer. The smoke that is generated here is distributed between the smoke layer and the smoke in the room.

The graph tells us how dense the smoke is. It can be used for evaluating the life safety in a smoke filled room, for instance will people be able to see the Exit signs.

The formula for visibility in smoke layers is *Visibility = 10/OD*.

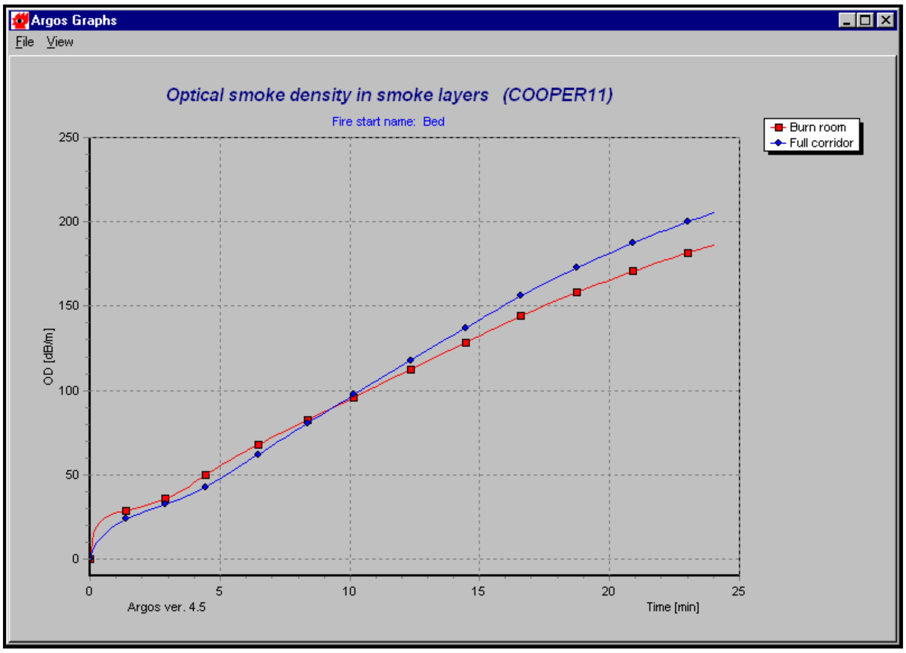


Figure 5.3: The Optical smoke density in smoke layers graph.

Distance from floor to smoke layers

This graph shows the distance from the floor to the smoke layer. In any given fire, the curve will start horizontally and then suddenly descend dramatically. When the curve breaks, the smoke layer has started forming.

The graph shows the speed with which the smoke layer reaches the bottom of the room. More importantly, it allows us to estimate the point of time when the smoke layer implies critical conditions. The critical condition figure equals 1.60 m + 10 % of the room height.

This graph is useful in scenarios used for evaluating life safety.

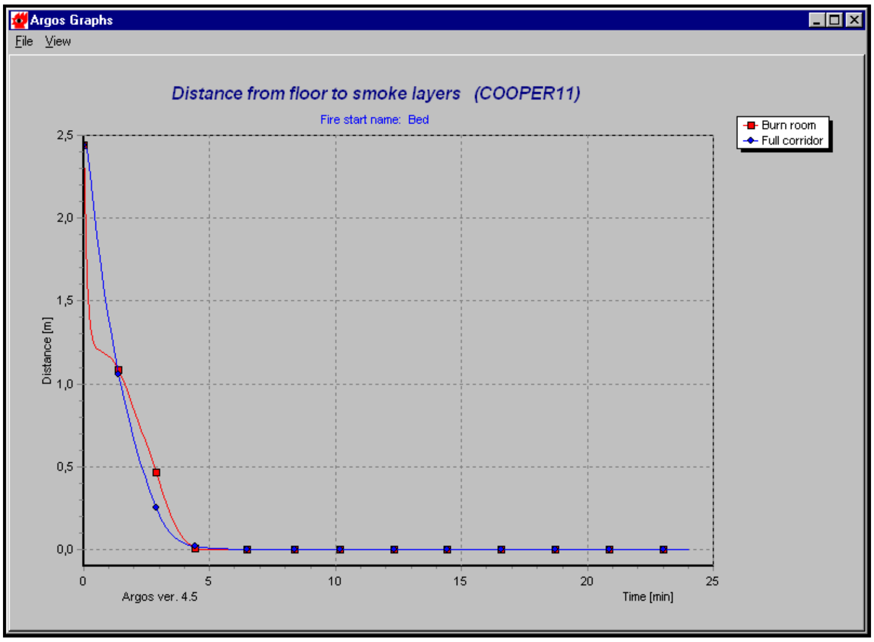


Figure 5.4: The Distance from floor to smoke layers graph.

Temperature in smoke layers

This graph shows the temperature in the smoke layer in any given fire. The graph will always start at room temperature and then gradually rise as the fire evolves.

The graph shows how hot it gets in the smoke layer. Since flash-over occurs at 500-600 °C, we may use the graph to evaluate what fire controlling devices should be considered to reduce the temperature.

The graph can also be used for evaluating the fire's impact on load-bearing and fire-separating structures.

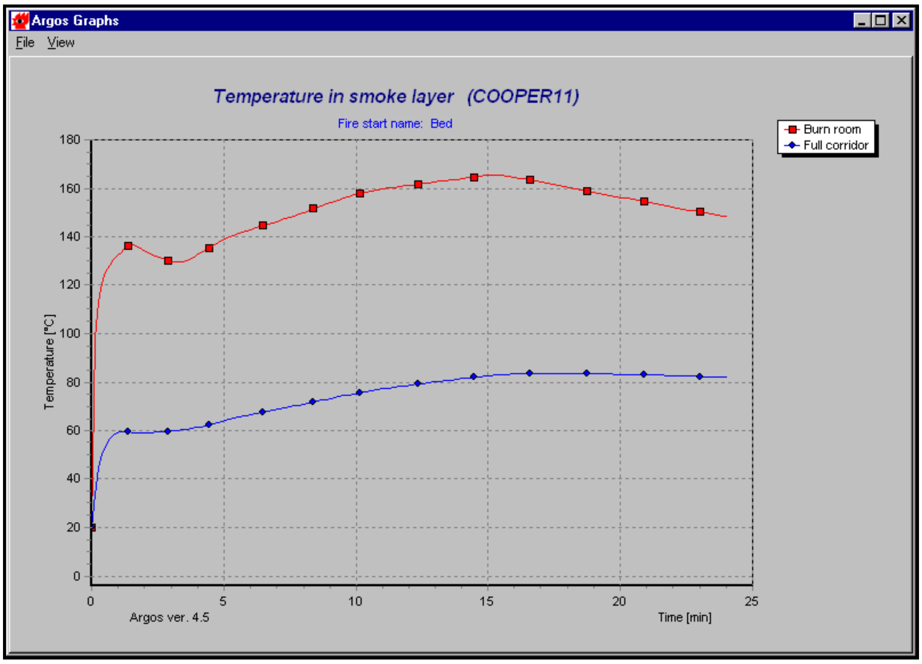


Figure 5.5: The Temperature in smoke layers graph.

Heat radiation from smoke layers

This graph shows the heat radiated from the smoke layers. There is no radiation from the smoke layer until it has been formed.

The radiation comes from the soot particles in the smoke layer. The level of heat radiation tells us something about the personal safety in the room. Flash-over will occur at approximately 15 kW/m^2. The fire brigade could not enter a room with a radiation level above 10 kW/m^2. For more information on radiation limits, please refer to the section *Radiation limits for humans and risk of fire spread* in *Chapter 7: Working in the Argos Database*.

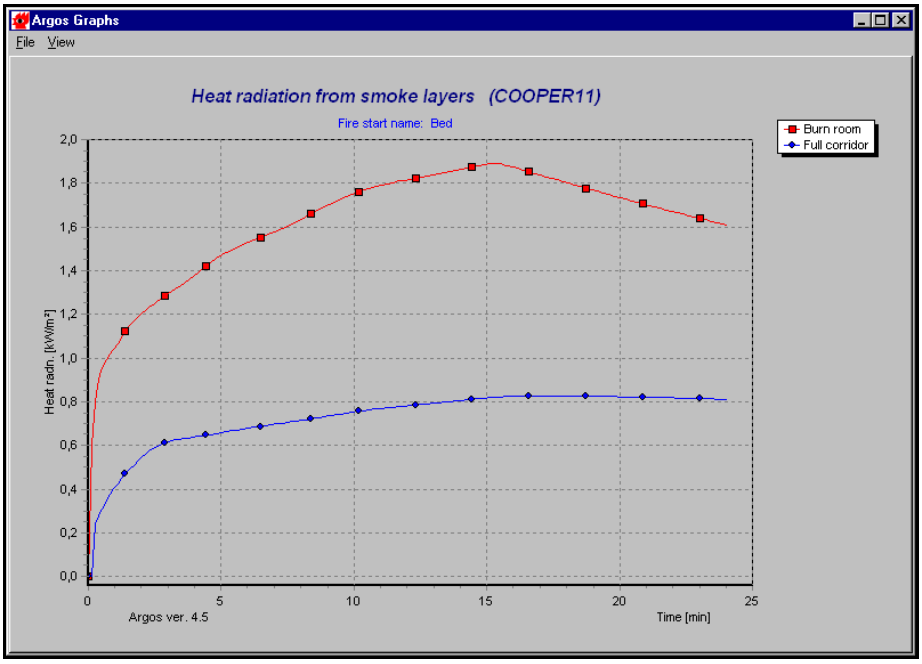


Figure 5.6: The Heat radiation from smoke layers graph.

Heat loss through surfaces

This graph shows the heat loss through the surfaces covered by smoke. The graph can be used to estimate how much energy is lost through the walls.

The heat loss will depend on which wall and ceiling materials you have chosen for your scenario.

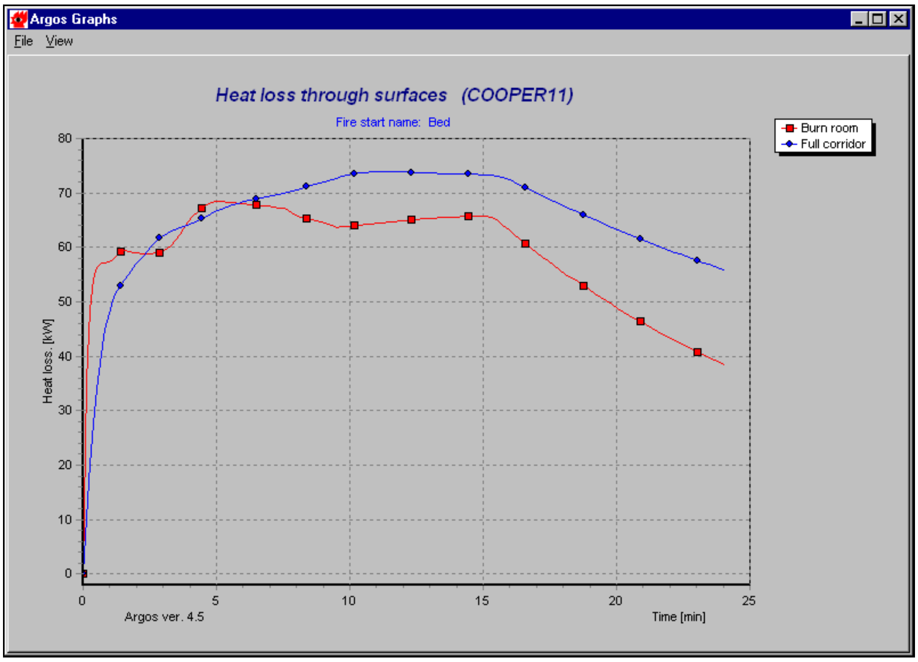


Figure 5.7: The Heat loss through surfaces graph.

Oxygen in rooms

This graph shows the oxygen level in the room as seen over time.

The graph tells us how much oxygen is available for humans. If the oxygen concentration is below 15%, we have critical conditions. The oxygen level also influences the development of the fire. If the level goes below 10.5 %, the rate of heat release will be reduced.

The graph is particularly relevant when evaluating personal safety.

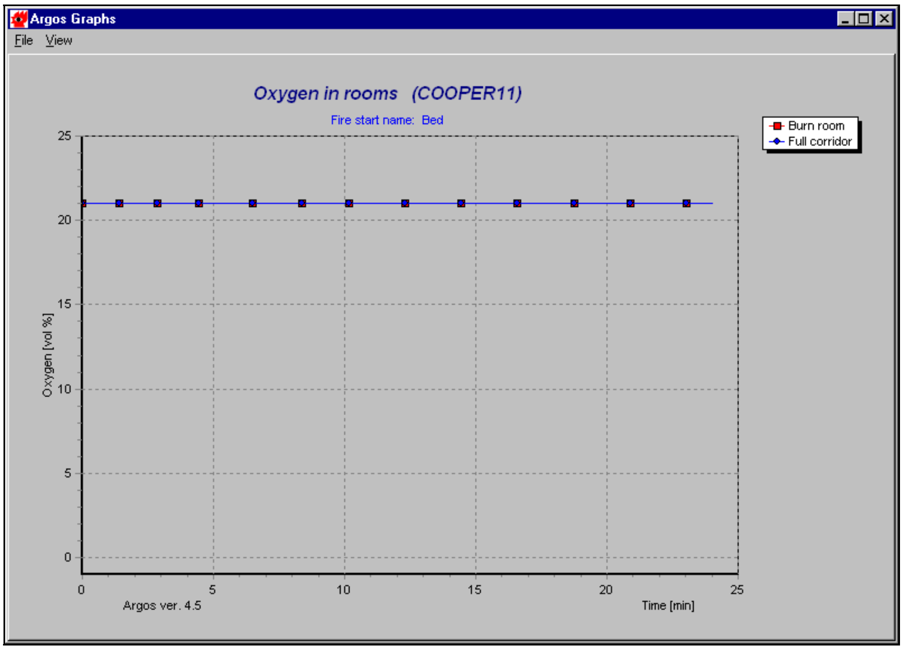


Figure 5.8: The Oxygen in rooms graph.

Oxygen in layers

This graph shows the oxygen level in the smoke layer as seen over time.

Note that if the smoke reaches the floor, the oxygen concentration in the smoke layer determines the heat release.

If the level drops below 10.5 % at this stage, the rate of heat release will be reduced.

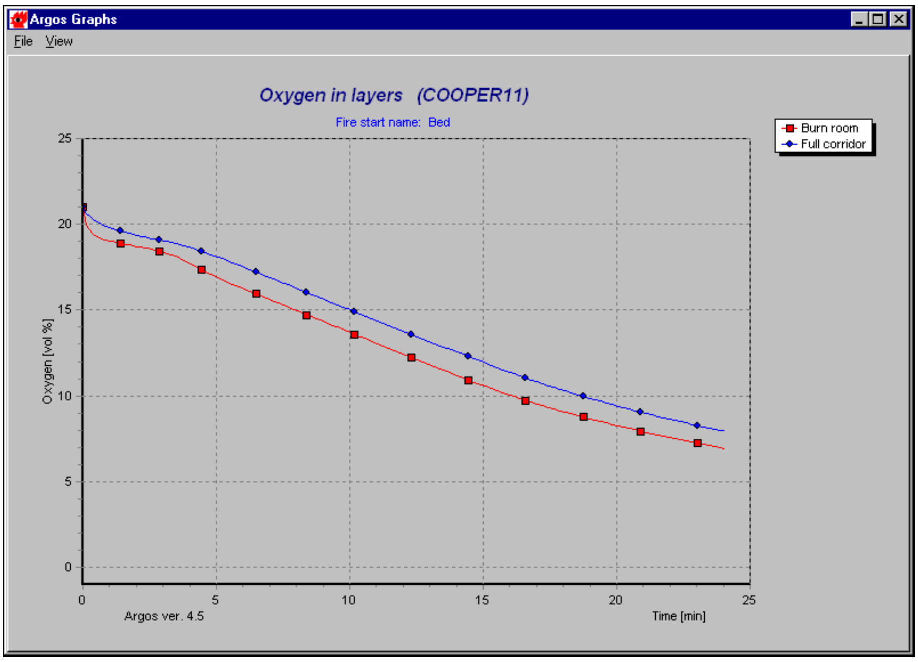


Figure 5.9: The Oxygen in layers graph.

Lower ceiling surfaces

This graph shows the temperature development on the lower ceiling surface. The temperature depends on the size of the fire and the material used for the ceiling. The temperature may be used to estimate what temperature the ceiling construction is exposed to. This can be used in subsequent calculations (outside Argos) to determine if the ceiling will lose its strength because of the estimated temperature.

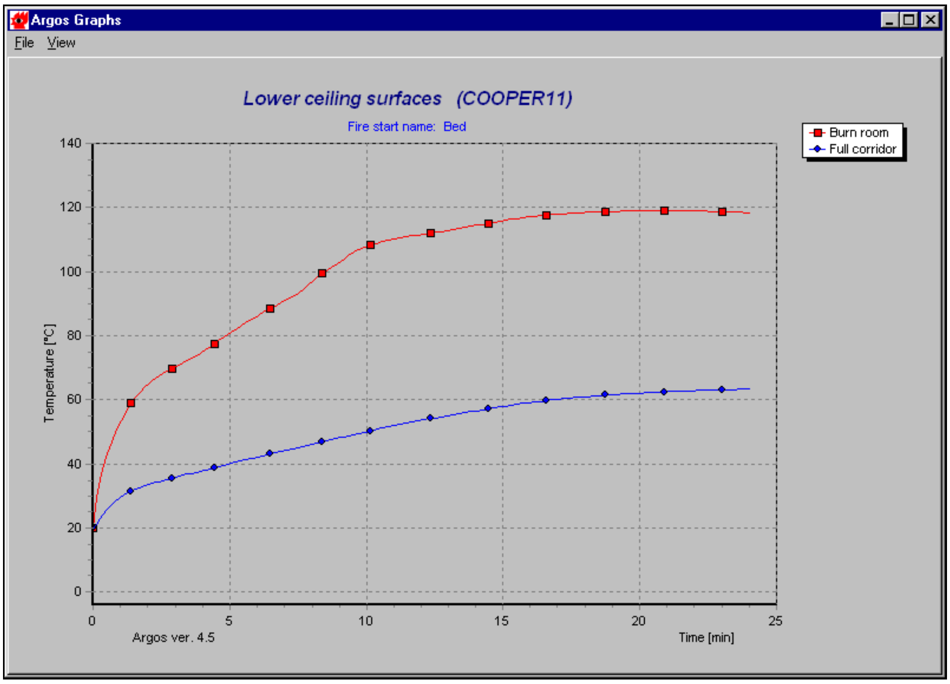


Figure 5.10: The Lower ceiling surfaces graph.

Upper ceiling surfaces

This graph shows the temperature development on the upper ceiling surfaces. The figure tells us if there is a possible risk of the fire spreading to other rooms. If the temperature at the upper ceiling surface reaches 300°C, there is a risk that items on the floor above the room will be ignited.

The important factor in this connection is the *thermal response* figure, which indicates whether the top of the ceiling material heats up quickly or slowly during a fire.

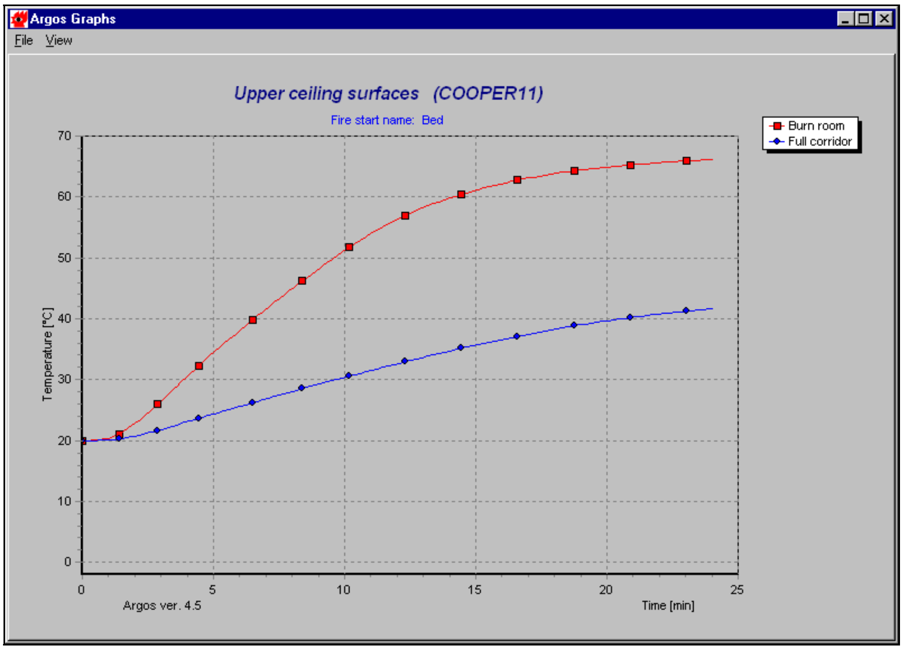


Figure 5.11: The Upper ceiling surfaces graph.

Ceiling temperature profile

This graph shows temperature across the ceiling. 0 mm is at the lowest part of the ceiling. The end of the curve projected to the X-axis represents the thickness of the ceiling. In figure 5.12, the value shown for the thickness of the ceiling is 13 mm.

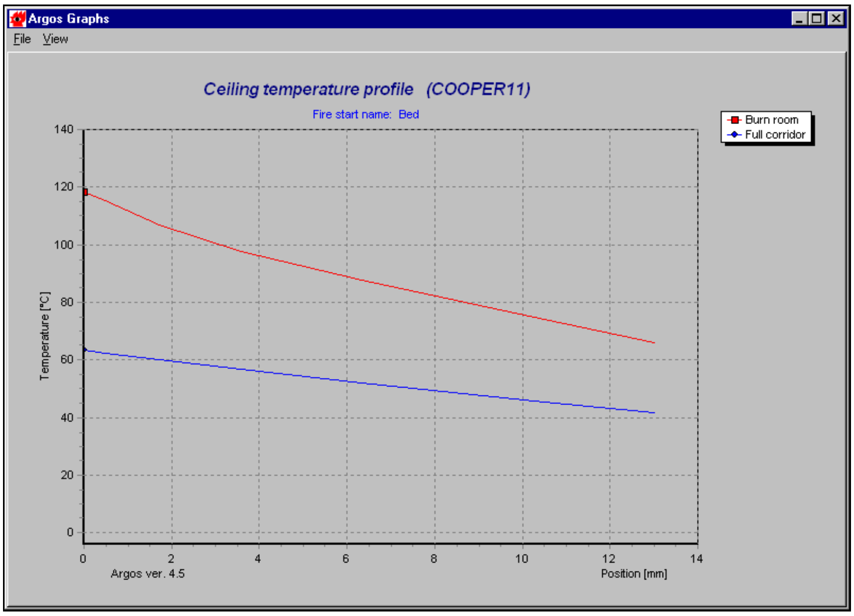


Figure 5.12: The Ceiling temperature profile graph.

Average temperature

This graph shows the average temperature of the air in the room. This temperature will be lower than the temperature in the smoke layer, since it is distributed over the entire room. At the same time, it will be higher than the temperature just below the smoke layer. This means that in order to get an upper limit of the temperature below the smoke layer, the average temperature can be used.

The following factors will have impact on the average temperature in Argos: The type of fire used for the simulation and the material used for the ceiling.

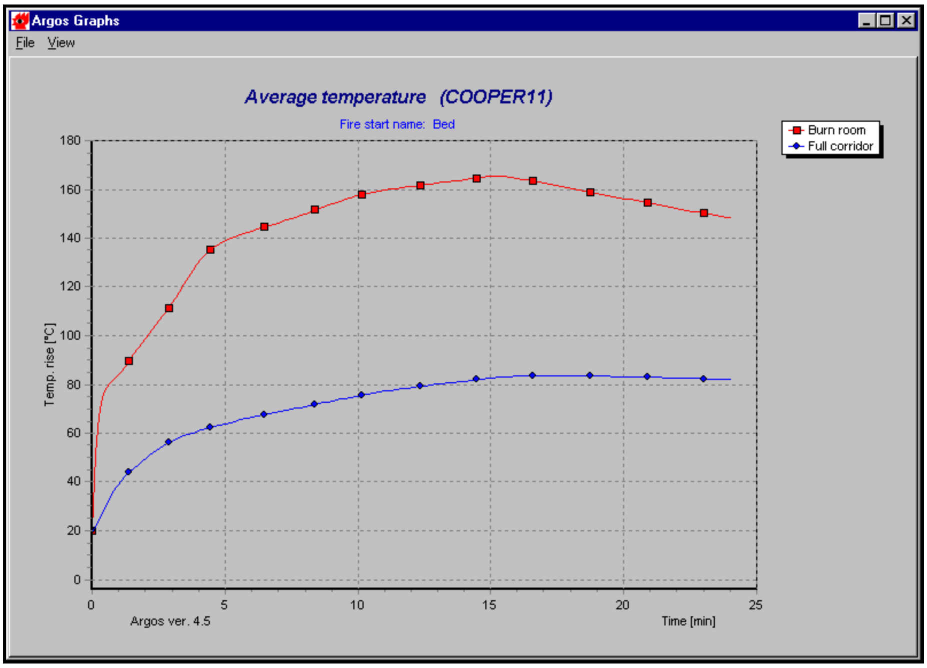


Figure 5.13: The Average temperature graph.

Floor pressure

This graph shows relative air pressure at the floor in all rooms. This pressure will have influence on smoke and heat transport between rooms via openings.

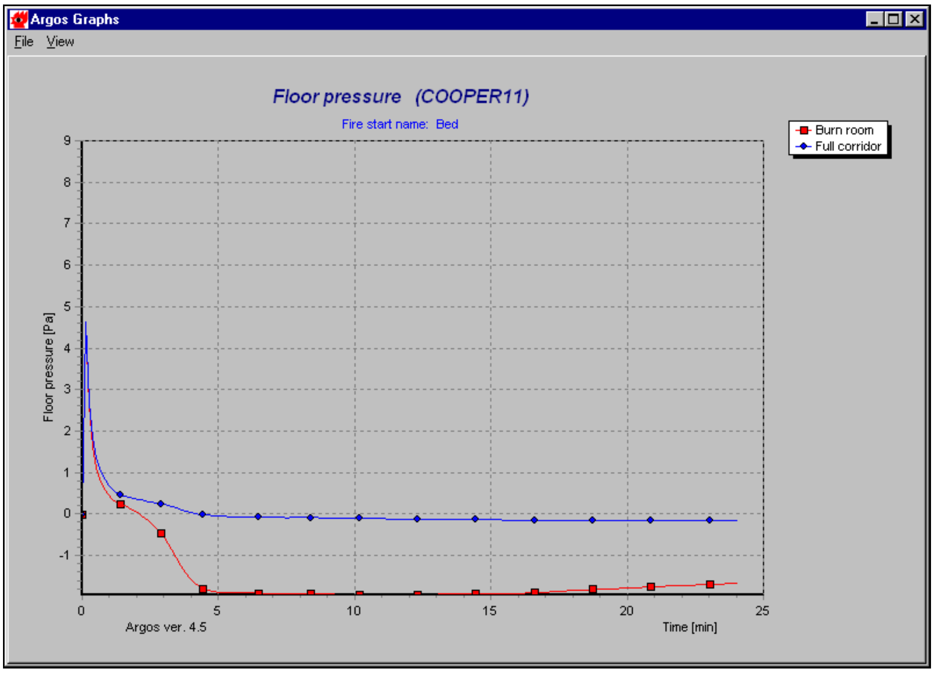


Figure 5.14: The Floor pressure graph.

Numerical integration step length

This graph shows the time steps that Argos takes during the entire simulation period. If there are great variations in the results, the time steps will be small. If little is happening, Argos will use bigger time steps.

For instance, in the graph below, at 1 minute, the time step is 1 second. At 4 minutes, the time step is 0.4 seconds.

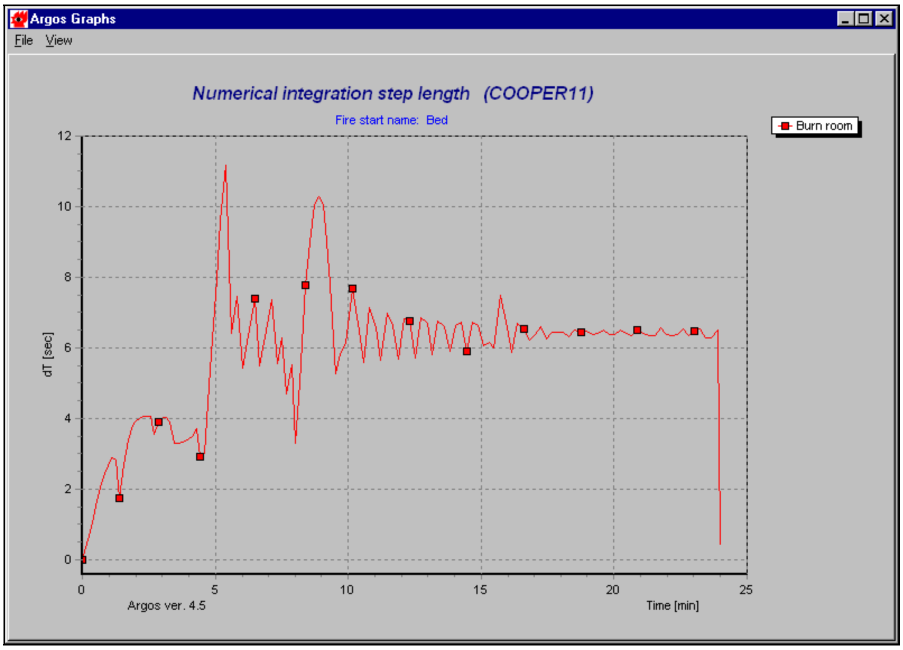
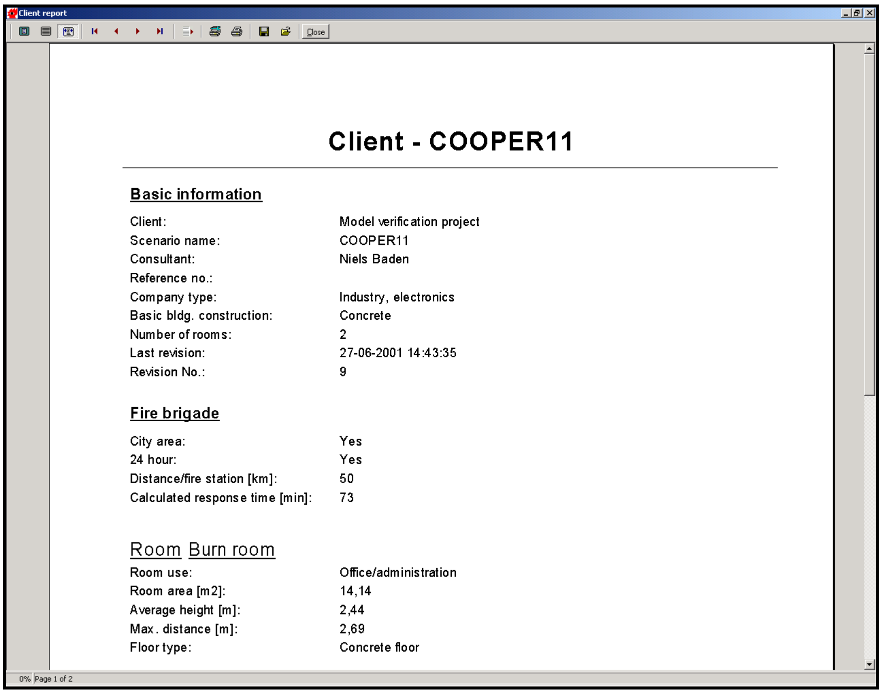


Figure 5.15: The Numerical integration step length graph.

Chapter 6: Presenting Your Work


Client report

Close

Client - COOPER11

Basic information

Client:	Model verification project
Scenario name:	COOPER11
Consultant:	Niels Baden
Reference no.:	
Company type:	Industry, electronics
Basic bldg. construction:	Concrete
Number of rooms:	2
Last revision:	27-06-2001 14:43:35
Revision No.:	9

Fire brigade

City area:	Yes
24 hour:	Yes
Distance/fire station [km]:	50
Calculated response time [min]:	73

Room Burn room

Room use:	Office/administration
Room area [m2]:	14,14
Average height [m]:	2,44
Max. distance [m]:	2,69
Floor type:	Concrete floor

0% Page 1 of 2

Figure 6.1: A scenario report

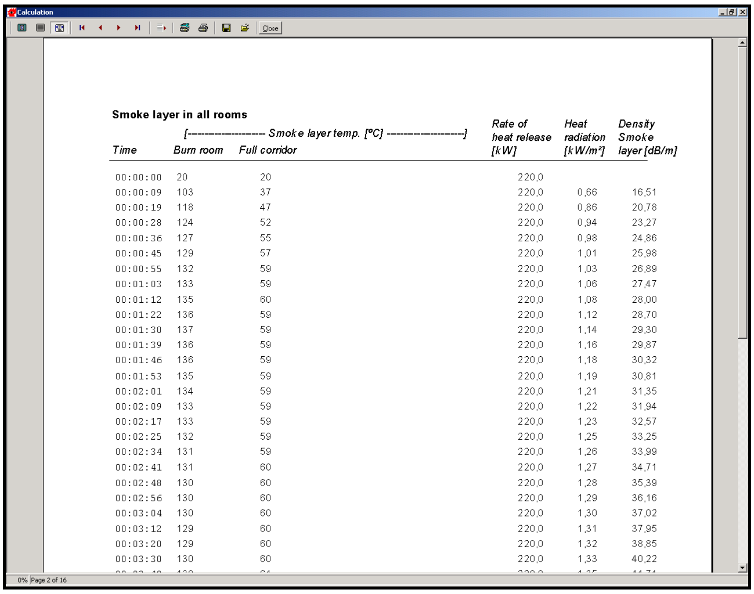
If you need to approach the authorities or a client with an application for constructing a new building, we recommend the following items be included:

- A scenario report detailing how the building is constructed.

  How? Use the **Print** button on the toolbar in the main window to print this report. You can then either print the report to a printer or a PDF file. Alternatively, you can save the report as an RTF file, which may be processed in MS Word.

- An appropriate number of simulation reports. Remember you can customize your scenarios and re-run them to get comparison results. One report for each simulation should be included.

  How? Use the **Report** button in the **Simulate fire** window to print these reports. You can then either print the reports to a printer or to a PDF file. Alternatively, you can save the report as an RTF file, which may be processed in MS Word.



Smoke layer in all rooms

Time	Burn room [------ Smoke layer temp. [°C]	Full corridor ------]	Rate of heat release [kW]	Heat radiation [kW/m²]	Density Smoke layer [dB/m]
00:00:00	20	20	220,0		
00:00:09	103	37	220,0	0,66	16,51
00:00:19	118	47	220,0	0,86	20,78
00:00:28	124	52	220,0	0,94	23,27
00:00:36	127	55	220,0	0,98	24,86
00:00:45	129	57	220,0	1,01	25,98
00:00:55	132	59	220,0	1,03	26,89
00:01:03	133	59	220,0	1,06	27,47
00:01:12	135	60	220,0	1,08	28,00
00:01:22	136	59	220,0	1,12	28,70
00:01:30	137	59	220,0	1,14	29,30
00:01:39	136	59	220,0	1,16	29,87
00:01:46	136	59	220,0	1,18	30,32
00:01:53	135	59	220,0	1,19	30,81
00:02:01	134	59	220,0	1,21	31,35
00:02:09	133	59	220,0	1,22	31,94
00:02:17	133	59	220,0	1,23	32,57
00:02:25	132	59	220,0	1,25	33,25
00:02:34	131	59	220,0	1,26	33,99
00:02:41	131	60	220,0	1,27	34,71
00:02:48	130	60	220,0	1,28	35,39
00:02:56	130	60	220,0	1,29	36,16
00:03:04	130	60	220,0	1,30	37,02
00:03:12	129	60	220,0	1,31	37,95
00:03:20	129	60	220,0	1,32	38,85
00:03:30	130	60	220,0	1,33	40,22

Figure 6.2: A simulation report

- Any documentation related to your simulation reports outlining why you have chosen to make the simulations you have carried out.

How? Type your documents in a word processor such as MS Word.

- Information about the selected fire(s). You can also include the fire graphs.

  How? Select the fire in the Argos database and click **Print** on the toolbar in the main window. You can then either print the reports to a printer or to a PDF file. Alternatively, you can save the report as an RTF file, which may be processed in MS Word.

- Simulation graphs. We recommend that you as a minimum include the following six graphs:
  - Rate of heat release
  - Optical smoke density in rooms
  - Optical smoke density in smoke layer
  - Distance from floor to smoke layer
  - Temperature in smoke layer
  - Heat radiation in smoke layer

  How? Click **Graph** in the **Simulate fire** window after each simulation.

Note!	To save a report as a PDF or an RTF file, click the diskette icon instead of the printer icon.

Chapter 7: Working in the Argos Database

The Argos database is where you create and maintain the data that is available in client mode: initial fires, heat detectors, building components, machines, room purposes, etc. The Argos database is stored in the Argos.gdb file, which is stored in the Argos program folder at C:/Program Files/Argos (on an English operating system.)

The Argos database also stores your scenarios.

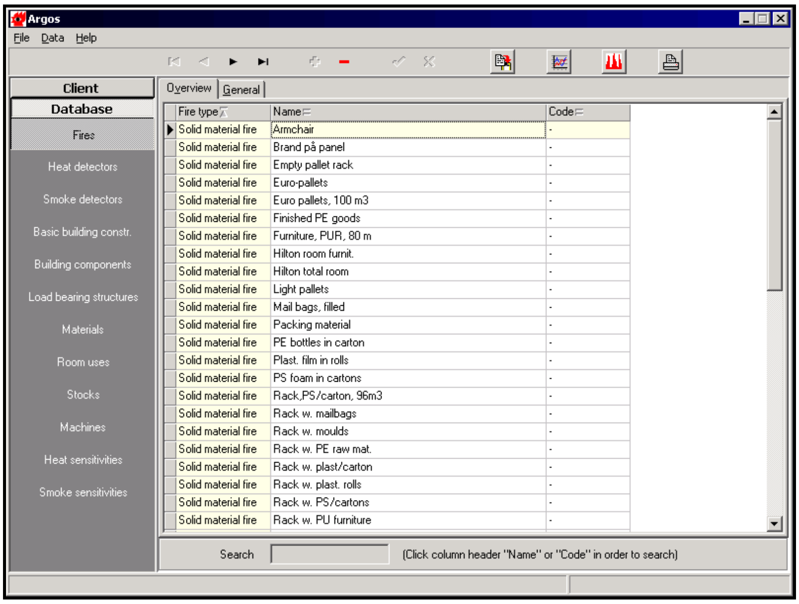


Figure 7.1: The main window of the Argos database.

Structure of the Argos Database

Argos comes with a large number of predefined records describing initial fires, stocks, machines, fire installations, and building components. If required, you may create your own records in the Argos database.

The Argos database holds records of the following types of information:

- Heat detectors
- Smoke detectors
- Basic building constructions
- Building components
- Load bearing structures
- Materials
- Room uses
- Stocks
- Machines
- Heat sensitivities
- Smoke sensitivities

Creating New Entries in the Database

As mentioned previously, you may create your own entries in the Argos database. The procedure is more or less similar across the different entry types.

1. Click the entry type in the left-hand Argos panel.
2. Click **Create** and proceed to the individual tabs to enter the appropriate information.
3. Click **Save changes**.

The Argos Help provides detailed information about the individual tabs, options, and parameters.

Creating Initial Fires

The initial fires in Argos fall in one of three categories: *semi-empirical models* (solid material fire, melting material fire, liquid pool fire, liquid tank fire, smouldering fire); *mathematical models* (energy formula); and *experimental data models* (data point fire).

Each fire is represented by the following information:

- Fire technical properties
- Physical dimensions

On the following pages we will describe the basic steps for creating the different types of fires.

Creating a solid material fire

The solid material fire model is especially suited for modelling of fires in objects with a large void fraction, for example piles of pallets or storage racks with combustible goods, where the combustible materials are separated by air-filled spaces.

To create a solid material fire:

1. Click *Fires* in the left-hand Argos panel.
2. Activate the *General* tab to enable the **Create** button.
3. Before clicking **Create**, select the appropriate tab, in this case the *Solid material fire* tab.
4. Click **Create**.
5. Type in the name of the new fire.
6. In the left hand side of the *Solid material fire* tab, enter the fire technical properties of the fire such as horizontal fire spread, heat release information, CO potentials, etc.
7. In the right hand side of the *Solid material fire* tab, enter the physical dimensions of the fire, such as height, width and length.

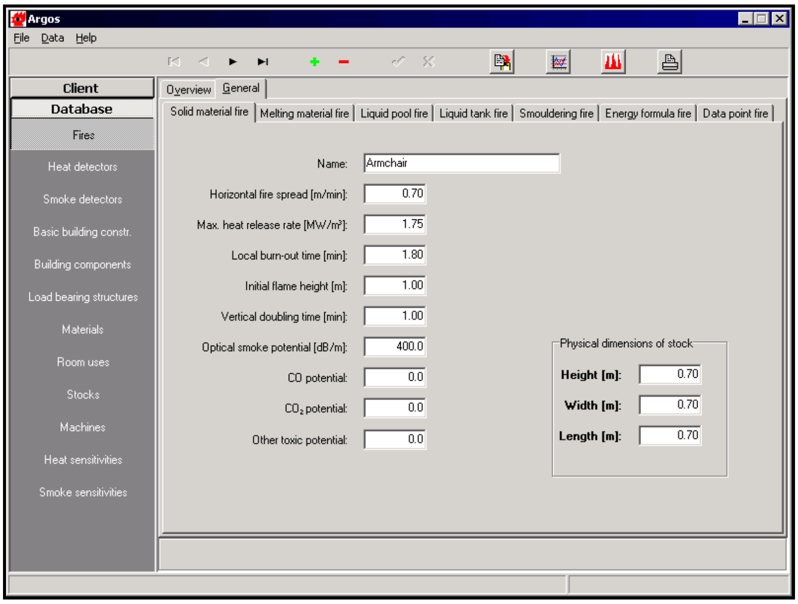


Figure 7.2: Use the Solid material fire tab to enter information about the solid material fire.

8. Click **Save changes**.

The new initial fire is now accessible in Client mode and may be used when simulating fires.

Creating a melting material fire

The model for fires in melting materials is especially suited for the modelling of fires in objects with a large void fraction, for example piles of polyethylene boxes, where the combustible materials are separated by air-filled spaces.

To create a melting material fire:

1. Click *Fires* in the left-hand Argos panel.
2. Activate the *General* tab to enable the **Create** button.
3. Before clicking **Create**, select the appropriate tab, in this case the *Melting material fire* tab.

4. Click **Create**.
5. Type in the name of the new fire.
6. In the left hand side of the *Melting material fire* tab, enter the fire technical properties of the fire, such as horizontal fire spread, heat release information, CO potentials, etc.
7. In the right hand side of the *Melting material fire* tab, enter the physical dimensions of the fire such as height, width, and length.

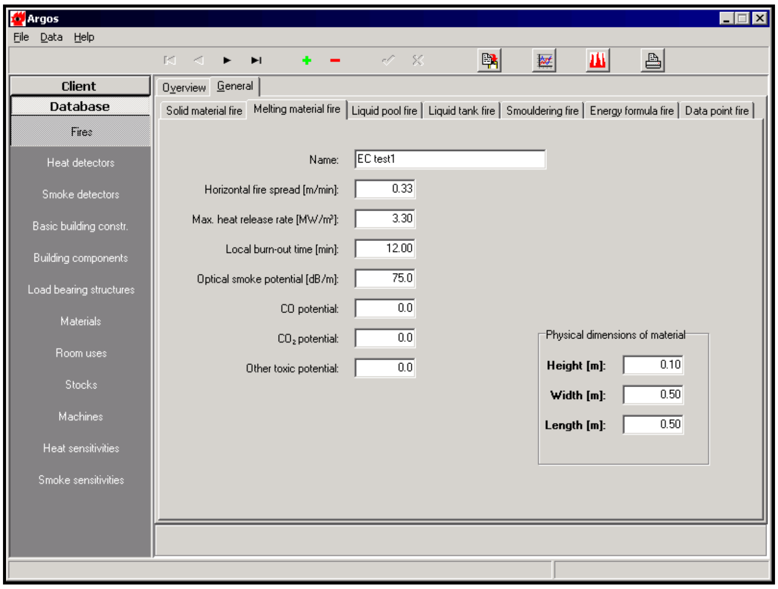


Figure 7.3: Use the Melting material fire tab to enter information about the melting material fire.

8. Click **Save changes**.

The new initial fire is now accessible in Client mode and may be used when simulating fires.

Creating a liquid pool fire

The model is based on fire in combustible liquid on a floor, where it will form a burning pool. The size of the pool and the effective heat of combustion determines the rate of heat release from the fire. The model also includes a minimum pool depth, which has a specific area for a given amount of fuel and a maximum fire area. The model limits the rate of heat release to a value corresponding to the smaller of the two areas.

To create a liquid pool fire:

1. Click *Fires* in the left-hand Argos panel.
2. Activate the *General* tab to enable the **Create** button.
3. Before clicking **Create**, select the appropriate tab, in this case the *Liquid pool fire* tab.
4. Click **Create**.
5. Type in the name of the new fire.
6. In the left hand side of the *Liquid pool fire* tab, enter the fire technical properties of the fire such as optical smoke potential, heat release information, etc.

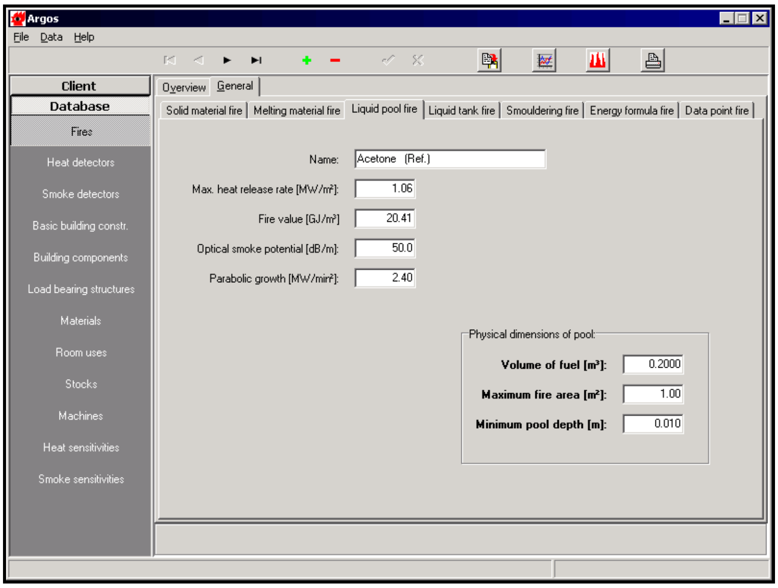


Figure 7.4: Use the Liquid pool fire material fire tab to enter information about the liquid pool fire.

7. In the right hand side of the *Liquid pool fire* tab, enter the physical dimensions of the fire such as height, width, and length.
8. Click **Save changes**.

The new initial fire is now accessible in Client mode and may be used when simulating fires.

Creating a liquid tank fire

The model for tank fires assumes that liquid is leaking from a vertical cylindrical vessel that has a hole in the bottom.

To create a liquid pool fire:

1. Click *Fires* in the left-hand Argos panel.
2. Activate the *General* tab to enable the **Create** button.
3. Before clicking **Create**, select the appropriate tab, in this case the *Liquid tank fire* tab.
4. Click **Create**.
5. Type in the name of the new fire.
6. In the left hand side of the *Liquid tank fire* tab, enter the fire technical properties of the fire such as optical smoke potential, heat release information, etc.
7. In the right hand side of the *Liquid tank fire* tab, enter the physical dimensions of the fire such as height, width, and length.
8. Click **Save changes**.

The new initial fire is now accessible in Client mode and may be used when simulating fires.

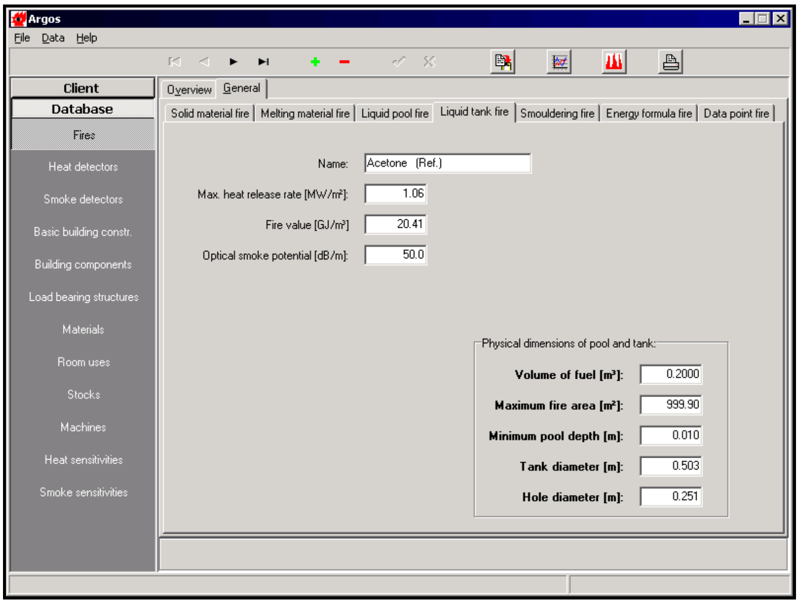


Figure 7.5: Use the Liquid tank fire tab to enter information about the liquid tank fire.

Creating a smouldering fire

A typical fire of this kind occurs when a cigarette is dropped onto a bed, which starts smouldering with a constant rate of heat release. This kind of fire is characterized by a low rate of heat release, which is seldom enough to create a smoke layer. Smouldering occurs without open flames, which gives poor and incomplete combustion of the burning items. This results in a high proportion of unburned and toxic gases such as CO.

Note! The *Smouldering fire* tab has no Physical dimension section. A smouldering fire is not regarded as having any physical dimensions.

To create a smouldering fire:

1. Click *Fires* in the left-hand Argos panel.
2. Activate the *General* tab to enable the **Create** button.
3. Before clicking **Create**, select the appropriate tab, in this case the *Smouldering fire* tab.
4. Click **Create**.
5. Type in the name of the new fire.
6. Enter the fire technical properties of the fire such as heat release information, optical smoke potential, CO potential, etc.

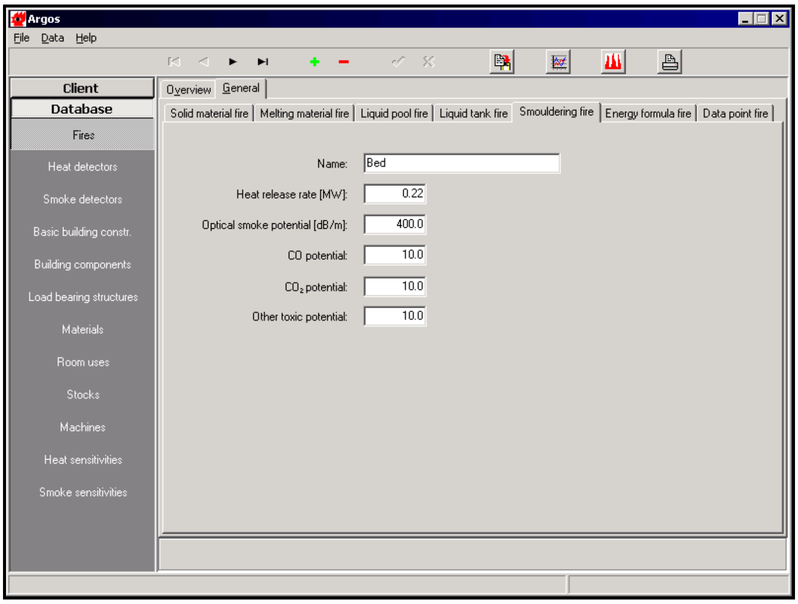


Figure 7.6: Use the Smouldering fire tab to enter information about the smouldering fire.

7. Click **Save changes**.

The new initial fire is now accessible in Client mode and may be used when simulating fires.

Creating an energy formula fire

Two types of energy formula fires can be defined, fire development following a second order polynomial or a doubling time formula. The second order polynomial is the most typical and covers the often used "alpha t-squared-fire", where the fire develops with a heat release rate of $Q= \alpha \times t^2$.

> **Note!** The *Energy formula fire* tab has no Physical dimension section. The area of an energy formula fire is equal to the rate of heat release of the fire divided by the rate of heat release per unit area.

To create an energy formula fire:

1. Click *Fires* in the left-hand Argos panel.
2. Activate the *General* tab to enable the **Create** button.
3. Before clicking **Create**, select the appropriate tab, in this case the *Energy formula fire* tab.
4. Click **Create**.
5. Type in the name of the new fire.
6. Enter the fire technical properties of the fire such as maximum effect, parabolic and linear growth, doubling time, etc.
7. Click **Save changes**.

The new initial fire is now accessible in Client mode and may be used when simulating fires.

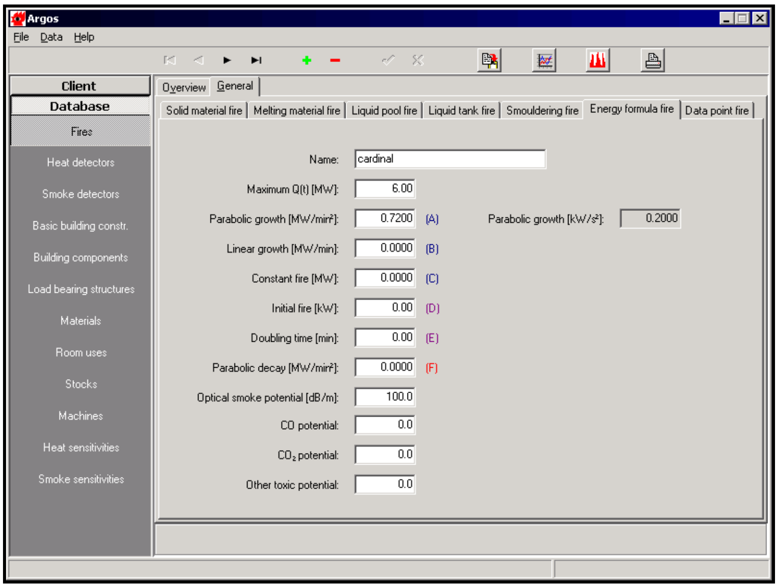


Figure 7.7: Use the Energy formula fire tab to enter information about the energy formula fire.

Creating a data point fire

This fire type can be used to enter sets of time and heat release rate, so that any type of heat release curve can be used in the program.

This is typically used to enter data from tests where the heat release has been measured over a period of time. Argos comes with more than 200 predefined data point fires. Most of them have been taken from the *Initial Fires* report by Stefan Särdqvist.

To create a data point fire:

1. Click *Fires* in the left-hand Argos panel.
2. Activate the *General* tab to enable the **Create** button.
3. Before clicking **Create**, select the appropriate tab, in this case the *Energy formula fire* tab.
4. Click **Create**.
5. Type in the name of the new fire.

6. Enter the fire technical properties of the fire such as optical smoke potential, CO potential, CO_2 potential etc.

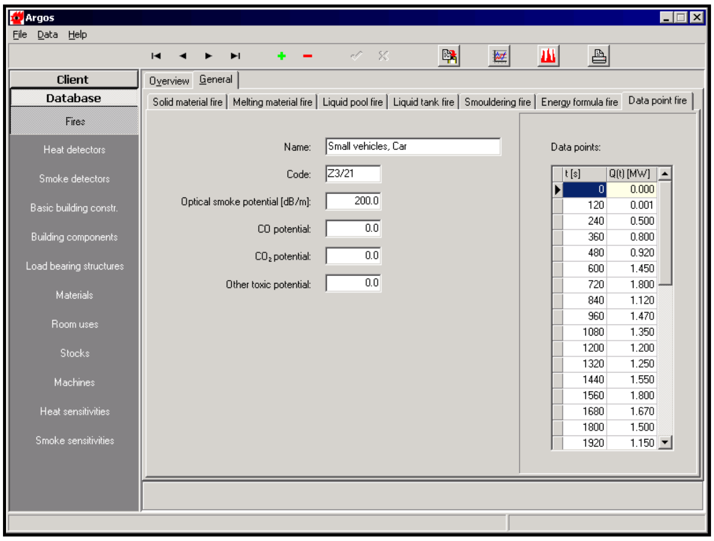


Figure 7.8: Use the Data point fire tab to enter information about the data point fire.

7. Click **Save changes**.

The new initial fire is now accessible in Client mode and may be used when simulating fires.

Copying an initial fire

Argos provides a means for copying the information from one initial fire to a new fire. With this time saving feature you may re-use all default values of the existing fire.

To copy an initial fire:

1. In the main window, select the initial fire you wish to copy.
2. On the toolbar, click the **Copy fire** button. The **Name of new fire** dialog box opens.

Figure 7.9: Enter a name for the new fire.

3. Enter the new name and click **OK**. The new fire is inserted in the main window.

4. Proceed to the *General* tab of the new fire and make the necessary adjustments.

5. Click **Save changes**.

The Fire Graphs in Argos

Argos includes five graphs that are available for all the different fire types except the smouldering fire. (A smouldering fire does not have flames and therefore only the graphs for Rate of heat release (RHR) and Accumulative energy release are available.)

All the fire graphs are for free burning fires. As opposed to this, all the graphs within the simulation window are for room fires, where there can be limited ventilation and therefore restriction on the amount of oxygen. If the amount of oxygen is reduced below a certain level, the fire will be reduced.

To launch the fire graphs, select the fire in the fire main window and click the **Show fire graphs** button.

The fire graphs of Argos are:

- Rate of heat release
- Accumulated energy released
- Fire area
- Flame height

- Safety distance

Rate of Heat Release

This graph shows the rate of heat release for a free burning fire during its life cycle. In Argos, there is no restriction on oxygen availability that, in a room fire, could reduce the rate of heat release.

Compared to the rate of heat release graph created during a simulation in a room, this graph will be either similar or more intense (higher values) because of the unlimited supply of oxygen.

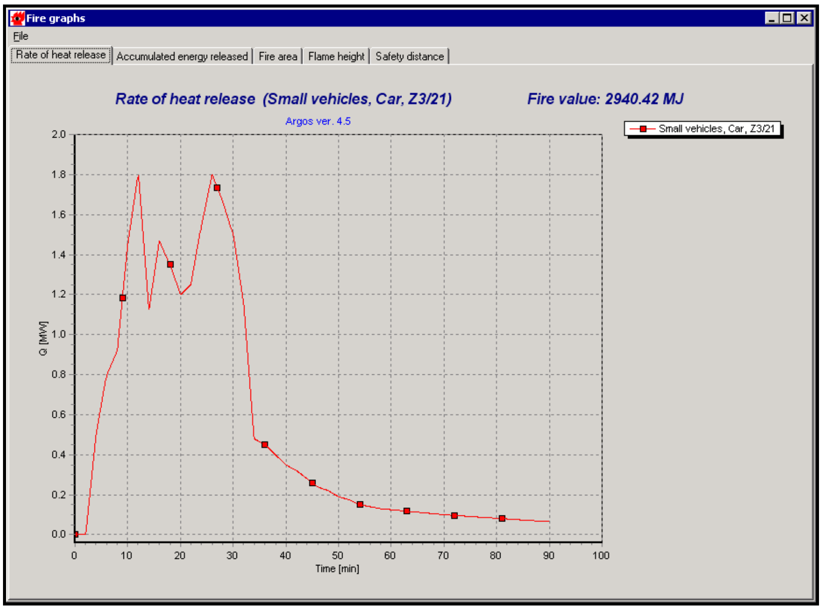


Figure 7.10: The Rate of heat release graph.

The area below the curve corresponds to the energy release in the fire. The total energy released by the selected fire is shown in the upper right corner as a fire value. See also the next section, Accumulated Energy Released.

Accumulated Energy Released

This graph shows the accumulated energy released for the current fire. More precisely, it illustrates the total energy released at a given point of time.

The accumulated energy release is the area below the rate of heat release curve until a given point of time. When the fire has burned out and all the energy has been released, the accumulated energy released reaches the fire value. This is also seen in the figure for the small vehicle which, at 90 minutes, has reached a value of nearly 3000 MJ, which matches well with the fire value (upper right corner) of 2940,42 MJ.

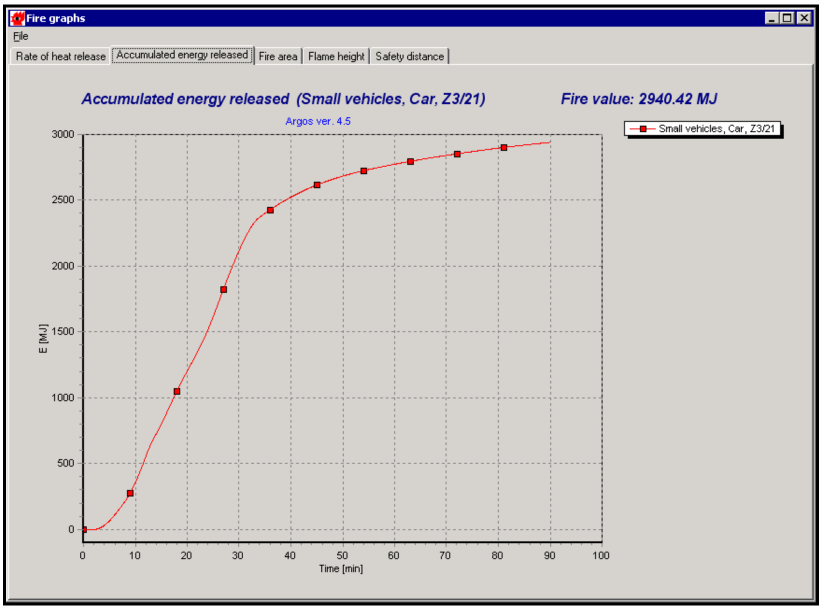


Figure 7.11: The Accumulated energy released graph.

The graph can be used to check that the total amount of energy in an item matches the actual energy released. For instance, if you create a fire in room with a given amount of fuel, such as 100 kg wood – then only the energy in the wood will be released. If the fire is then modelled with $\alpha\ t^2$ with a maximum rate of heat release, then this fire should end when the accumulated energy released matches the total energy in the wood. Assuming an energy content of 14 MJ for 1 kg of wood implies that when the accumulated energy released reaches 100 kg* 14 MJ/kg = 1400 MJ, then all wood has been burned and the fire should stop.

Fire Area

This graph shows the fire area of the current fire. The graph can be used to show how big an area a given fire will cover. It is also used by Argos to calculate the flame height.

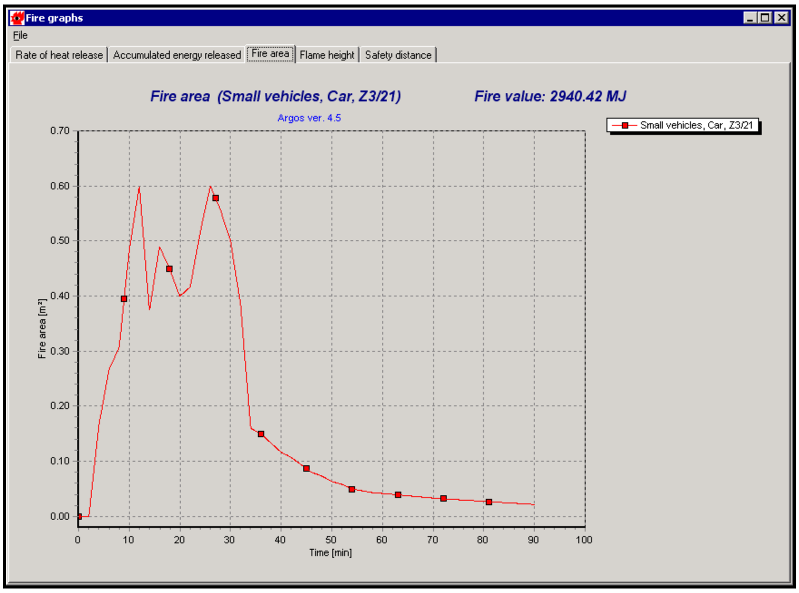


Figure 7.12: The Fire area graph.

The semi-empirical fire models in Argos such as solid material fires, melting material fires, liquid pool fires and liquid tank fires contain information about the fire area in the models itself (e.g. given rate of heat release per fuel area for different fuels).

For the energy formula fire and the data point fire, however, there is no information on the fire area. The areas for these fires are based on the rate of heat release per area, which is entered into the Parameter's menu (see *The Parameters Command* section in Chapter 1.) When carrying out performance based design without knowledge of the specific fire load, the rate of heat release per area can be used. For shops, malls etc. this could be set to 500 kW/m2, which matches the average rate heat release per area in a building of this type. For other objects, such as tunnels, this value could be significantly higher.

Flame Height

This graph shows the calculated flame height of the current fire. The graph can be used to estimate if flames will reach the ceiling and lead to flames along the ceiling.

The flame height is used to calculate the safety distance.

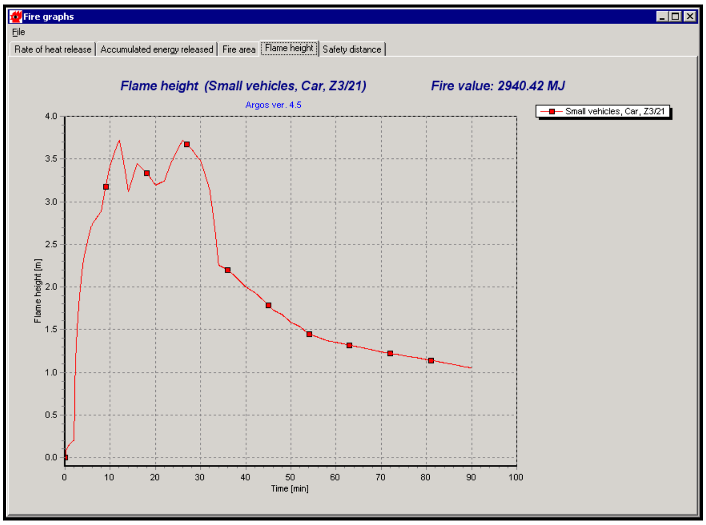


Figure 7.13: The Flame height graph.

Safety Distance

This graph shows the safety distance for the current fire. You can determine the safe distance for humans and also the risk of the fire spreading any further.

In Argos, the safety distance is measured from the edge of the fire to the person or object. Other models calculate the safety distance from the middle of the fire.

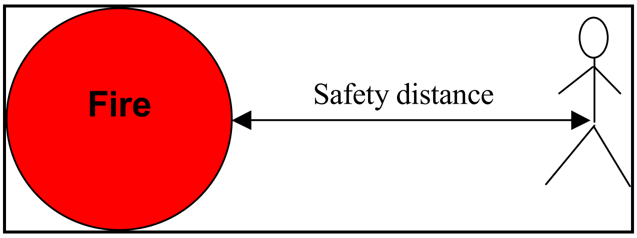


Figure 7.14: Safety distance.

Looking at graph 7.15 and using a radiation limit of 1 kW/m^2 for humans, shows that a person should be more than 6 meters away from the burning car to avoid burn injuries.

To ignite another object, the radiation level should be above 15 kW/m^2. From the graph, it can be seen that the safety distance for this level of radiation is about 80 cm – meaning that if the car were parked in a parking lot, the fire would probably ignite the car next to it. But it would not ignite other cars, if they were not parked next to the burning car (more than 1 free space away).

Radiation limits for humans and risk of fire spread

Safety distances are defined in Argos as the distance from the edge of the flaming zone (in meters), for 5 different levels of radiation.

The safety distance can be used to see how distant humans have to be from a fire so that they are not affected e.g. during an evacuation.

The safety distance for a radiation level of 15 kW/m2 can be used to determine the risk of nearby objects being ignited.

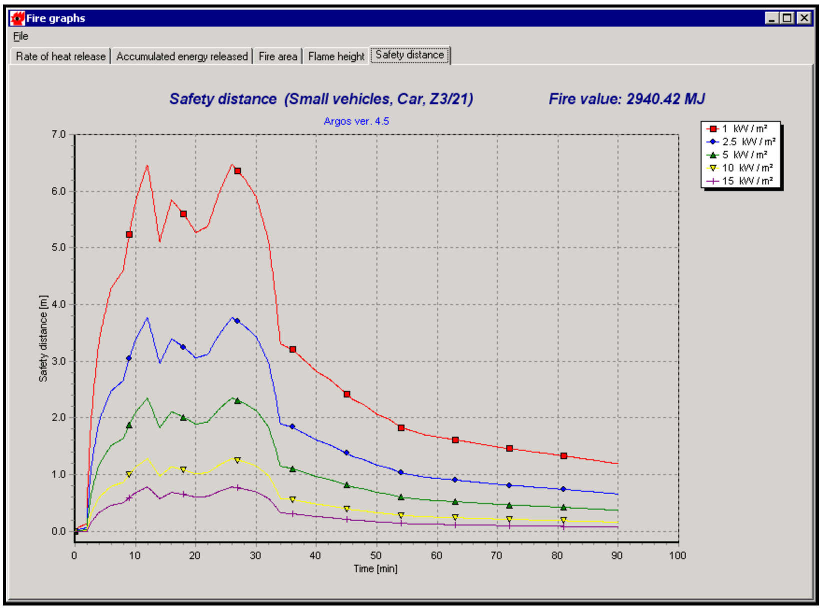


Figure 7.15: The Safety distance graph.

Exposure of humans

- 1 kW/m^2 for indefinite skin exposure
- 2.5 kW/m^2 for a maximum of 5 minutes.
- 5 kW/m^2 is a typical upper limit for short-term exposure (maximum 10s exposure).
- 10 kW/m^2 is a typical upper limit for fire fighters in protective clothing.

Risk of flame spread

- 15 kW/m^2 is a typical lower limit for pilot ignition of combustible materials.

Chapter 8: Backing Up Your Work

The key to your work in Argos is the *argos.gdb* file. This file stores both your scenarios and the Argos database. Thus the key to protecting your work is to make sure that *argos.gdb* is never damaged (or deleted).

Argos never communicates directly with this file but sends queries via the database engine. This protects the data from corruption – even if the computer should fail in the middle of a transaction, the database engine will just roll the data back on restart.

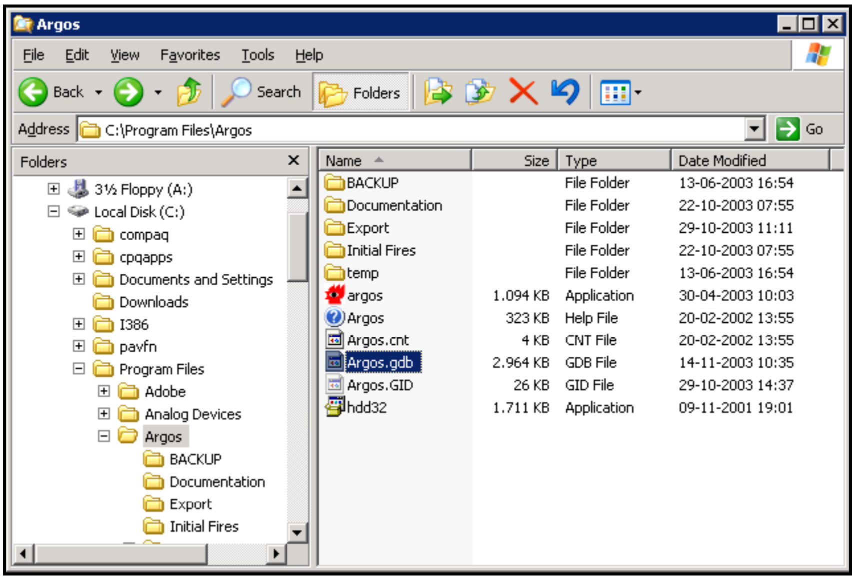


Figure 8.1: Argos.gdb is stored in the Argos program folder at C:/Program Files/Argos.

Backing up your work

To back up your work:

1. Close Argos.
2. Launch Windows Explorer and go the Argos program folder at C:\Program Files\Argos.
3. Select *Argos.gdb* and copy it to a safe place.

Moving Your Work to Another Computer

To move your work to another computer:

1. Close Argos.
2. Launch Windows Explorer and go the Argos directory at C:\Program Files\Argos.
3. Select *Argos.gdb* and copy it to the clipboard or save it to a diskette or a network drive. If you have access to the other computer from you current work station, you may simply drag and drop the file to the new location.
4. Copy *Argos.gdb* to the Argos program folder on the new computer: C:\Program Files\Argos. Now all the data are available on the new computer.

Note!	The directory path to the Argos folders depends on the language of your computer's operating system. By default, the Argos folder will be located where all your other programs are installed. For instance, on a Danish computer the path is C:\Programmer\Argos and on a Swedish computer it is C:\Program\Argos.

Glossary

Active fire precautions	Active system to discover, extinguish or alert in case of fire.
Active systems	Automatic system, activated by fire, such as an automatic fire alarm system, automatic total flooding system, automatic sprinkler system, or automatic fire ventilation.
Ambient zone	The ambient zone is outside the building where the temperature is constantly at 20°C. At the beginning of the fire there will also be ambient conditions below the smoke layer.
Automatic fire alarm	Detects smoke or heat from the fire and alerts the fire brigade or an internal alarm.
Automatic fire ventilation	Automatic venting of smoke and heat from the fire.
Average temperature rises	The average temperature for the smoke layer and the zone below the smoke layer over time.
Fire safety engineering	Engineering calculation, judgement within fire safety.
Ceiling temperature	Temperature of the ceiling surface in the enclosure.

Ceiling temperature profile Temperature profile through the ceiling construction.

Client mode Mode for setting up a model of an enclosure for fire modelling, e.g. entering the geometry in Argos.

Cold smoke Smoke without enough buoyancy to generate a two-zone model.

Combustion zone Same as fire zone. Not modelled separately in Argos.

Compartment ambient zone Zone below the smoke layer.

Computer simulated fire Fire development and spread in an enclosure modelled in a computer.

Critical conditions Conditions where human ability to egress starts to decrease rapidly.

Damage report A report that lists the loss of building, stocks and machines by a fire (in $ and %).

Data point fire Points of time versus energy released (typical data from experiments).

Database mode Mode for setting up materials, building components, fire, sprinklers etc. for usage in the model of enclosure.

Design fire The fire that is used as the starting fire in Argos.

Distance from floor to smoke layers	Height from floor level to smoke layers.
Energy formula fire	Fire development described by a mathematical formula e.g. αt^2.
Evacuation simulation	Simulation of egress from a building.
Fire growth	Increase of fire with time.
Fire installation	Active system installed in the building in Argos; includes automatic smoke venting, sprinklers, and automatic fire alarms.
Fire precautions	Passive or active system.
Fire simulation	Simulation of fire development and spread within the model of enclosure.
Fire simulator	Software for making fire simulations, e.g. ARGOS.
Fire zone	Zone where the fire is located, i.e. where the smoke and energy are generated and released. Not modelled separately in Argos.
Flash-over	Transition to a state of total involvement in a fire of combustible materials within an enclosure.
Floor pressure	Pressure in the rooms, measured at floor level.

Geometry	The building that is to be modelled. This includes rooms, average room height and connections between the different rooms.
Heat detector	A detector that responds at a certain temperature.
Heat loss	Heat transported to the surroundings.
Heat loss through surfaces	Heat transported from the room through the surfaces to the surroundings.
Heat radiation	Heat transportation from a warm media to a cold media as radiation.
Heat radiation from smoke layers	Heat radiation from the hot smoke layer to the floor in Argos.
Hot gas zone	Upper warm layer containing heat and smoke.
Initial fire	Same as design fire, starting fire. This is the fire that burns at the onset of the fire and until the fire reaches flash over.
Liquid pool fire	Fire in a pool containing liquid, e.g. oil.
Lower ceiling surfaces	The inner surface of the ceiling.
Maximum distance or Max distance	Maximal distance that smoke shall travel to reach a boundary, i.e. from the centre of the fire to the corner furthest away from the fire.

Melting material fire	Fire where the material melts when heated, e.g. a candle.
Numerical integration step length	Time step between results made by ARGOS during the calculation.
Optical smoke density	Measure of the attenuation of a light beam passing through smoke expressed as the logarithm $\log_{10}$ (I/T) of the opacity of smoke.
Optical smoke density in rooms	The amount of smoke (smoke particles equally spread in the room) measured as light damping through the smoke.
Optical smoke density in smoke layers	The amount of smoke in the smoke layer (smoke particles equally spread in the smoke layer) measured as light damping through the smoke.
Oxygen in layers	The amount of oxygen in the smoke layer.
Oxygen in rooms	The amount of oxygen in the room or in the zone below the smoke layer when a smoke layer has been formed.
Passive fire precautions	Fire precautions based on passive systems.
Passive systems	Fire protection systems that do not need to be activated by the fire e.g. an EI60 wall.
Plume	A fire plume is the buoyant flow from a fire, including any flames.

Post flash-over simulation	Simulation of fire scenario after flashover has occurred.
Post flash-over	The period after flash-over has occurred.
Post flash-over model	A computer model that describes the fire after flash-over has occurred.
Pre-flash-over	The period before flash-over has occurred.
Pre-flash-over simulation	Simulation of fire scenario before flash-over has occurred.
Rate of heat release	Total energy released per unit time by an item during combustion under specified combustions (in watts).
Room geometry	The basic geometry measurements for a room which is to be modelled, e.g. area and height of the room.
Scenario	A given setup for a geometry, specifying which doors are open, which fire installations are active and an initial fire.
Self-closing doors	Doors that initially are open and will be closed on fire indications, such as smoke or temperature or by a person (timer).
Simulation options	Different options that can be altered within the simulation.
Smoke density	The optical density (OD) of the smoke measured in db/m.

Smoke detector	A detector sensitive to particulate products of combustion and/or pyrolysis suspended in the atmosphere.
Smoke layer	The hot upper layer that grows in volume and descends from the upper boundary (ceiling) towards the floor.
Smoke Transport	Transportation of smoke from a given point to another.
Smoke Transport Modelling	Modelling smoke transport from the fire to the smoke layer or from the room of fire origin to another room.
Smoke venting devices	System for releasing heat and smoke from the model of enclosure. This could be either thermal (openings, such as skylights, high placed windows) or mechanical, i.e. ventilators.
Smouldering fire	Smouldering – combustion of a material without flame and without light being visible.
Solid material fire	Fire in a solid material, i.e. wood.
Sprinkler system	Automatic fire extinguishing system. The system is activated by heat and releases water that, if reaching the fire, decreases the energy release.
Surroundings	The area outside the room or building. There are ambient conditions in the surroundings.

Temperature in smoke layers	The average temperature of the upper hot layer that contains smoke.
Toxicity	Ability of a substance to produce adverse effects upon a living organism.
Upper ceiling surfaces temperature	The temperature of the surface on a ceiling construction at the top side, away from the fire.
Venting	Ventilating smoke and heat away from the room or enclosure.
Visibility	Ability to see through smoke.
Zone model	Description of fire scenario including propagation of fire in a number of zones with different characteristics. A two-zone model describes a lower, cold zone (mostly free of smoke) and an upper, warm zone (containing the smoke generated).
Zone modelling	Mathematical modelling of the fire scenario in zones.

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