

Apros[®] Product Specifications

This is a general technical specification that defines the Apros[®] products and services available. The software is provided as executable programs, program libraries and example data files. The documentation is provided as files suitable for reading by Internet browsers. Software and documentation are delivered on optic or magnetic media or via Internet.

Apros products consist of two categories: (1) **Apros Simulation Products** and (2) **Apros Add-On Products**. Both categories include several products. This product specification covers all Apros products and the related expert services.

The key software is the **Apros Simulation Software** that has been customised for the different application areas of the **Apros Simulation Products**: Apros Basic, Apros Thermal and Apros Nuclear. **Apros Add-on Products** have been developed for the specific needs, i.e., the Apros Team Server, the Apros Testing Station software, the Apros Instructor's Station software, and the ProcSee Display Emulation software. The Add-on Products communicate with Apros Simulation Products. The specified Product, Functionality, Scope of Use, and License Type determine the applicable license rights and fees.

Apros Simulation Software

Apros Simulation Software is not a single product, but includes several products customised for different application areas.

The main components of the Apros Simulation Software are (1) **Apros Simulation Solver**, (2) **Apros Modeller Interface**, (3) **Apros Generic Library**, (4) **Apros Communication Interface Libraries**, and (5) **Apros Application Specific Model Libraries**. Each Apros Simulation Product includes a different combination of the main components. VTT Technical Research Centre of Finland Ltd and Fortum Power and Heat Oy jointly develop the Apros Simulation Software. Apros[®] is a registered trademark of VTT and Fortum.

Apros Simulation Solver

The numerical solvers of Apros are based on basic physical principles models. They are optimised for applications in various fields, such as nuclear power, thermal power, bioenergy, pulp & paper production, chemical industries and smart built environments with decentralised energy production including renewable energy sources. The models are based on the conservation laws for masses, momentum and energy, supported by material property data, empirical parameters and correlation functions. The methods employed represent the present state-of-the-art in mechanistic modelling and simulation.

- **Thermal hydraulics 3-equation solver** includes a one dimensional homogeneous 3-equation model.
- **Thermal hydraulics 6-equation solver** includes a one dimensional separate phase flow 6-equation model for water including non-condensable gases.

Apros Simulation Solver can make use of several available processor cores with parallel computing. The main schemes available are parallel computing within one Apros process (e.g. parallelisation of the automation, homogenous model and material properties) or several Apros processes utilising MPI based parallelisation (6-equation model). The schemes can be combined to optimise the simulation speed on the hardware available.

Apros Modeller Interface

Apros Modeller Interface (AMI) provides a CAD like functionality for model specification and execution of simulation experiments. The model is specified by drawing process, automation and electrical system diagrams, and filling in data sheets with relevant model component parameter values. AMI communicates with the Apros Simulation Solver. AMI in Apros versions 6 and higher replaces the Grades modeller interface of version 5. The Grades modeller interface software was made for Apros by a third party and it is not developed any more.

Apros Generic Library

Apros libraries are combined to form the basis of the Apros Simulation Products for different purposes. Apros Generic Library is composed of the following parts:

- **Executive system** provides the control of simulation, storage and retrieval of data associated with the model parameters and structure, simulation experiment specification, design of simulation sessions, model and initial condition management, and recording of the simulation results.
- **Equation solver** provides other Apros packages with tools for solving large systems of sparse linear equations arising from discretisation of partial differential equations with respect to space and time. The equation solver is needed for efficient thermal hydraulics simulation.
- **Thermal hydraulics packages** provide means for solving flows of fluids, heat conduction in solid structures and heat transfer between fluid and structures.
- **Sequential tank dynamics package** for a single-phase flow is also included. It is sufficient when the momentum equations in the flow can be neglected.
- **Predefined fluid properties packages** including, e.g., water/steam, flue gases, water and air, saline water and air, oxygen, carbon dioxide, liquid metals, are available in a wide operation range with respect to pressure and enthalpy, within the homogeneous 3-equation model.
- **REFPROP database package interface** for pure fluids of the NIST Reference Fluid Thermodynamic and Transport Properties Database (REFPROP) is available. Means for defining user's own fluids (e.g., thermal oils and molten salts) as well as structural materials (e.g., metals and insulators) are also provided. REFPROP database is provided upon request (free of charge).
- **Process component package** provides generic component models, such as pipes, valves, separating tanks, mixing connection points, heat exchangers, pumps, compressors, and turbine sections.
- **Automation system package** provides a large set of components, needed for the modelling of measurements and signals, control system elements, logic system elements, sequential automatics, and interfaces to the controlled devices.
- **Electrical system package** provides calculation of frequency and load flow in the electrical network feeding process components such as pumps and valves. A comprehensive set of generic electrical system components is available: lines, bus bars, breakers, transformers, and generators. Both AC and DC systems can be simulated.
- **External DLL package** provides a mechanism for users to include their own functional blocks in the simulation model. They can be used efficiently as part of the Apros computation after each time step and also within Apros automation solution. The blocks can be coded with any programming language (typically with C++ or Fortran).
- **User component feature** enables users to make customised and reusable components. User components are an efficient way to develop re-usable building blocks that can be exported for other modellers and provide a means to build user's own customised component libraries.
- **Specific features** including, e.g., the modelling of heat structure stresses and diesel engines. Please ask your distributor for details.
- **Simantics Constraint Language (SCL)** is a script language, e.g., for configuring model structures, modifying model parameters and running simulation experiments via a user-definable script. It provides programming tools that have a direct access to Apros database both for configuring the model and simulation. SCL is available from version Apros 6.06.

Apros Communication Interface Libraries

- **ACL Library** is an Apros specific communication interface library intended for high-performance communication between the Apros Simulation Engine and client programs that use the library. Through the services of the library, the client program can remotely across a network give Apros commands, receive responses to them and exchange data with the Apros Simulation Engine either as individual values or in blocks. The library can be used in a heterogeneous network: the operating systems of the client and server hosts may be different, and the same library can be used for connecting to the Apros Simulation Engines that run on different operating systems. The library is delivered with headers for either C or Fortran programming language, and it is available on every operating system on which Apros presently is available. Ready made products with ACL library embedded may be distributed without additional license charges.
- **OPC Library** is an OPC based communication interface library that enables easy connectivity to third party software. It is supported, e.g., by automation software vendors. The Microsoft Windows versions of various Apros Simulation Products have a specific interface that conforms to the OPC Data Access, OPC XML DA and OPC UA specifications.

Apros Application Specific Model Libraries

Apros Application Specific Model Libraries provide extensions to Apros Generic Library, and they are included only in specific Apros Products. The following Apros Application Specific Model Libraries are currently available:

- **Combustion Library** includes one-dimensional boiler components including air and flue gas ducts, heat exchangers, relevant fluid and structural material property calculations, reaction calculation including combustion of fuel gas, oil, pulverised coal, and other solid fuels, bubbling and circulating fluidised bed components, gas turbines.
- **Nuclear Library** includes Nuclear process components, 1D-neutronics/nuclear reactor models, 3D-neutronics/nuclear reactor models, containment models, and severe accident models. Various Apros Nuclear products are available each containing a specific set of the Nuclear library components.

Apros Simulation Products

Each Apros Simulation Product is intended for modelling and simulation purposes of a certain application area. Apros Simulation Products are software packages that can be used independently. They are all built on the Apros Simulation Software main components, such as Apros Generic Library and thus contain several common software components. Apros Modeller Interface and Apros Communication Interface Libraries are included in all products. The following Apros Simulation Products are available:

Apros Basic

- **BAS: Basic** includes the Thermal hydraulics 3-equation solver and extends the Apros Generic Library with components for the modelling of
 - district heating elements and energy storages
 - fuel cells
 - photovoltaic solar panels and thermal solar collectors
 - multi-stage flash distillation (MSF) and reverse osmosis desalination
 - water, air and flue gas networks.

Apros Thermal (former Combustion)

- **THE:** Thermal extends Basic with
 - Thermal hydraulics 6-equation solver
 - Combustion Library.

Apros Nuclear

- **NUC: Nuclear** extends Thermal with a 1D nuclear reactor model
- **NCO: Nuclear + Containment** extends NUC with the Containment model
- **N3D: Nuclear 3D Reactor** extends NUC with the 3D reactor model.
- **N3C: Nuclear 3D Reactor + Containment** extends N3D with the Containment model.
- **N3S: Nuclear 3D Reactor + Containment + SA** extends N3C with VVER specific Severe Accident models.

Table 1 specifies the products Apros Basic (BAS), Apros Thermal (THE) and Apros Nuclear (NUC) in detail. Table 2 specifies the Apros Nuclear versions NUC, NCO, N3D, N3C, and N3S.

	Apros Basic	Apros Thermal	Apros Nuclear*
	BAS	THE	NUC
Apros Simulation solver	X	X	X
Thermal hydraulics 3-equation solver	X	X	X
Thermal hydraulics 6-equation solver	-	X	X
Apros Modeller Interface (AMI)	X	X	X
Apros Generic Library	X	X	X
Combustion library	-	X	X
Nuclear library See Table 2 for the product versions and details of Nuclear Power Plant specific components and solvers.	-	-	X
Apros Communication Interface Libraries	X	X	X

Table 1. Apros Simulation Products: "X" means the feature is included, and "-" excluded.

	Apros Nuclear	Apros Nuclear + Containment	Apros Nuclear + 3D	Apros Nuclear + 3D + Containment	Apros Nuclear + 3D + Containment + SA
	NUC	NCO	N3D	N3C	N3S
Nuclear Process Components	X	X	X	X	X
1D-Reactor Neutronics and components	X	X	X	X	X
3D-Reactor Neutronics and components	-	-	X	X	X
Containment Model solver and components	-	X	-	X	X
Severe accident (SA) models for VVER-type NPP's	-	-	-	-	X

Table 2. Apros Nuclear product versions. As all Apros Nuclear product versions are extensions of Apros Thermal (THE) product, all features of THE are included (see Table 1).

Apros Add-on Products

Apros Add-On Products are special software intended to be used together with Apros Simulation Products and they feature built-in capabilities for the communication. They are not intended to work as stand-alone products, i.e., they are not simulation software and cannot be used to model or simulate any applications. The following Apros Add-On Products are currently available:

Apros Team Server

- **ATS: Apros Team Server** helps systemise and automate Apros modelling project tasks: version management, change histories, change tracking, differences reporting, user management, and ticketing system. Recording of model changes and model version management are fully automated. ATS enables focusing on modelling work and it makes team work more effective.

Apros Testing Station Software

- **ATEST: Apros Testing Station** is a tool for the planning and execution of test runs and monitoring of the testing progress. By using the tool a virtual commissioning can be planned ahead and performed in a systematic way. The tool has a number of features for supporting the visualisation of the results and reporting and auditing of tests. Accordingly it makes the validation and regression testing of the application models very efficient. It has features for managing the simulation assisted testing of digital automation systems.

Apros Instructor's Station Software

- **AINS: Apros Instructor's Station** is intended for Apros training simulator applications. The Instructor's Station Software manages the running of Apros simulation engine, possible virtual automation systems and other simulation software. One can specify malfunctions, simulation runs and scoring criteria. When executing simulation runs specified, comparisons can be made to reference data and feedback received on the performance.

ProcSee Display Emulation Software

- **PRS: ProcSee** process computer display emulation software runs on Windows 7, 8 and 10 computers. It has been developed by the OECD Halden Reactor Project. The same License and Maintenance Terms apply as for Apros.

Scope of Use

Following Scopes of Use are available:

- **EDU: Education** license is available to all Apros Simulation Products. The Education license restricts the use strictly to public educational purposes and public theses work of enrolled university (or comparable) students. Apros models developed and relevant research reports shall be made available for the Distributor.
- **BUS: Business** license is intended for any other use than EDU, regardless if the work is covered by industrial or governmental funding. For instance, engineering consulting and safety analysis services, development of training and/or testing simulators, and provision of courses for design engineers and plant operators are all considered as business use.
- **DEMO: Demonstration** license is for a restricted version of Apros Thermal that can only be used for becoming acquainted with Apros, evaluation, demonstration and public educational purposes. The maximum size of the model is constrained as well as the communication properties. Only a WS license type and DEV functionality are available (see below). Other technical restrictions may exist.

License Types

Following License Types are available:

- **WS: Workstation** license allows for one stand-alone installation for a single user on a specified computer.
- **WG: Workgroup** license allows for up to five installations on specified computers, all connected to the same local network.

Each installation is tied to a specified computer on which the software is installed, and it can be used on that computer only. The computer is identified by a machine id generated by the Apros installation program. In case the license allows for multiple installations, a License Server is installed on a computer in the local network. This computer must be powered on and the License Server must be running whenever any installation is used, and the IP address of the computer must remain the same over time.

Functionality

Following Functionalities of an installation are available:

- **DEV: Development** license is intended for simulation model developments for engineering and R&D purposes to assist efficient evaluation of process and control system design concepts and implementations, building operator training applications, use for training purposes, making process analysis etc. Changes in the model parameters or structure can be made through the Apros Modeller Interface (AMI), command console, remote applications or text-format specifications. Specification files of the whole model or a part of it can be saved and loaded. Binary snapshots of the model state can be saved and loaded. Maintenance Agreement at least for the first 12 months of use is required for the delivery of a new once paid Development license.
- **R-T: Run-time** license of the Apros simulation solver is available in which changes in the model structure are prevented through any means. The software may be connected to real, emulated or simulated control system equipment in a professional training simulator. Apros Simulation Software may operate as

an OPC or ACL server. The model parameter values can be changed, and snapshots of the model state can be saved and loaded. Maintenance Agreement is not required for Run-Time licenses but is, however, strongly recommended.

Requirements on user's hardware and software

It is expected that the computers for using Apros Simulation Products have a minimum 4 GB of memory per intended concurrent modelling and simulation application and 64-bit operating system. Recommended computer configuration contains 8 GB of memory per application. Environmental requirements stated by the computer vendors apply. Apros runs on Intel Pentium compatible processors and Windows Vista, Windows 7, Windows 8, and Windows 10 operating systems. Note that Grades modeller interface development has ended and it is only supported up to Windows 7.

For the parallelisation features of Apros there should be at least 1 dedicated core per parallelisation thread or process that is started through MPI.

Expert Services

Training of end users

Each distributor may provide training on the products as agreed. Training on the use of all software products of the Apros software is available from the supplier. The training may be agreed to take place either at the end user's, distributor's or supplier's site.

Maintenance service

Maintenance Agreement is mandatory for the first 12 months regarding the Development functionality licenses of Apros. The first maintenance period starts upon delivery and continues for at least 12 full calendar months. In order to synchronise the maintenance periods with the calendar year, the following maintenance period is terminated at the end of the accordingly commenced calendar year. Thereafter the agreement continues annually if not terminated before the end of the previous period as set forth in the Software Maintenance Agreement Terms. If the maintenance agreement has been interrupted, the acquisition of a new version requires the procurement of a new license.

License key service

The license keys for running the software products can be obtained from the supplier through the distributors. The maintenance service entitles to one request and delivery of license keys annually, e.g., in connection to a version upgrade. The supplier charges a fee for each additional request to cover the expenses for the operation.

Consulting services

Consulting services to support development projects may be ordered from the distributor. Either per day basis services at your site or per hour basis remote services are available. Actual travelling and lodging costs for the experts involved will be charged as well.

Model development

A fixed price proposal on model development is also possible in cases where the extent of the model can easily be specified.

Independent analysis

Distributor may also offer to perform simulation runs with a developed model in order to analyse the performance of a process in specified conditions and scenarios.