

FILTER DESIGN SOFTWARE

Solid-Liquid Separation Equipment Selection – Design – Simulation - Education – Training

Filter Design Software (FDS) has been developed from the successful p^C-SELECT software that has been used by numerous filtration equipment and user companies since it was launched in 1991. FDS is a result of a collaboration with companies in the equipment supply, pharmaceutical, fine chemical and mining industry sectors where the software has been tested during its development.

FDS is an aid to equipment specification and is also a training and educational tool for use by both industry and academia – so it contains many explanations, pictures and diagrams of equipment. The simulation procedures have in-built constraints that arise due to equipment design features that affect the operation of the equipment, along with many guides to aid correct input of data.

FDS is industry tested, intelligent and interactive software that is designed to be user friendly for those users who may not be familiar with the bewildering choice that exists amongst solid-liquid separation equipment. FDS is also a valuable tool for the solid-liquid separation equipment expert.

FDS is a sequence of interlinked modules that can be used independently from one another. The full set of FDS modules offers many capabilities, including:

- A catalogue and explanation of the main operational and design features of 70+ equipment types
- Full analysis capabilities of leaf filter, jar sedimentation and expression test results to give the relevant parameters for scale-up and simulation of solid-liquid separation equipment
- Comparison of data sets from a range of tests or trials
- Simulation of 20+ types of vacuum and pressure filters
- The ability to import data files from other software (e.g. Excel[®] spreadsheets)
- Web access to equipment suppliers.

SELECTION MODULE & EQUIPMENT CATALOGUE

The equipment catalogue, which can be called up from the opening screen, is designed for use as a reference manual - it gives technical information and diagrams and photographs about all of the generic types of equipment stored in FDS.

Specifications

Feed rate (m³/h): 5-50
 Operation: batch
 Objective: washed solids
 Settling rate (cm/s): 0.1-5
 Supernatant clarity: good
 Sludge proportion (%): 2-20
 Filtration: Cake growth rate (cm/min): < 0.02

Selected equipment list: 13 items

| | Warning | (1) | (2) | (3) | (4) | (5) | Particle size (um) | Solids conc. (%w/w) |
|---|---------|-----|-----|-----|-----|-----|--------------------|---------------------|
| Basket (pendulum) centrifuge | None | 3 | 5 | 6 | 6 | 25 | 10-1000 | 4-30 |
| Circle beam thickener | None | 1 | 5 | 2 | 3 | 17 | 0.1-2000 | <20 |
| Diaphragm filter press | None | 8 | 8 | 8 | 7 | 31 | 1-200 | 0.3-30+ |
| Filter press | 18 | 6 | 8 | 8 | 8 | 30 | 1-100 | <1-30+ |
| High gradient magnetic separator | 1h | 1 | 5 | 4 | 2 | 8 | <400 | <10 |
| Low gradient/internally magnetic separator | 1h | 3 | 4 | 2 | 8 | 17 | <40-4000 | 5-20 |
| Low shear crossflow microfilter | 1h | 1 | 5 | 9 | 2 | 8 | 0.05-20 | <30 |
| Multi (horizontal) element leaf pressure filter | None | 5 | 8 | 8 | 8 | 23 | 1-100 | <3-20 |
| Multi (vertical) element leaf pressure filter | None | 8 | 8 | 6 | 8 | 27 | 0.5-100 | <1-20 |
| Multi element leaf vacuum filter | None | 5 | 7 | 5 | 8 | 25 | 1-100 | 5-30+ |
| Screen classifier | 18G | 5 | 5 | 4 | 4 | 18 | 45-100000 | 20-40 |
| Single leaf (Nutsche) pressure filter | None | 6 | 8 | 8 | 8 | 30 | 1-200 | <1-20+ |
| Tube press | 18B | 8 | 7 | 4 | 7 | 26 | 1-200 | 0.3-30+ |

Equipment descriptions

Variable volume filters and presses - general
 A family of filters devised to handle suspensions of filter solids that are difficult to pump and/or filter. Typical feeds include suspensions of gelatinous and fibrous materials and those particulates containing occluded liquids within an inherent porous structure.

Diaphragm filter press
 Typical uses Batch processing of suspensions forming compressible filter cakes where dry cakes and/or efficient post-treatment are required

Process ratings
 Solid product dryness and state: 8 C
 Washing performance: 8
 Liquid product quality: 8
 Crystal breakage: 7

Feed properties
 Particle size range: 1-200 um
 Solids concentration range: 0.3-30+ %w/w

These machines are similar in form and general operation to filter presses. However, the plate surfaces are modified by the addition of flexible diaphragms to form membrane plates. Although variants exist, feed pumping operations are generally stopped after 80% of the required volume of filtrate has been produced. The

Equipment schematic 1
 Diagram showing the Diaphragm Filter Press (filtration/washing/holding) with labels for wash water, feed, discharge cake, and filtrate.

Annotations:

- Specify application requirements of the equipment
- Save results to file
- General information about equipment highlighted in the 'selected equipment' box
- Detailed information on operational and design features of the highlighted equipment
- List of equipment selected that meets your application requirements
- Prioritise the list by factors most important to your application
- Diagrams and photographs of the equipment highlighted
- Web addresses of suppliers of equipment highlighted

Example of an equipment selection results screen

The equipment selection procedures enable selection from more than 70 solid-liquid separation equipment types, including thickeners, centrifuges, hydrocyclones, etc – there are many more if the variants within each type are counted. Selection is possible from either limited or from more extensive information – obviously, the more information that is available about the feed and the process the better the selection!

Key features in the Selection Module include:

- User specification of the process and the duty that the equipment will be expected to perform
- Automatic comparison of the specifications with the FDS database
- Ranked listing of solid-liquid separation equipment that match the specifications
- General and detailed information about solid-liquid separation equipment - technical design and operational information about each equipment item in the list is provided in a descriptive format on screen, together with diagrams and photographs
- Facility to prioritise the equipment list according to process criteria (such as cake washability, cake dryness or the damage likely to be caused to the particles)
- Identification of equipment in the list that is marginal for technical reasons
- Customisable list of web addresses of equipment suppliers and facility to paste suppliers addresses to the web browser.

DATA ANALYSIS MODULE

The tests carried out early in the assessment of a solid-liquid separation problem – for either equipment selection or to gather design data – are either a constant pressure leaf filter test (sometimes pilot scale tests may be available) and/or a jar sedimentation test. A piston press test is sometimes carried out to assess compression or consolidation effects on the separation. Whichever test is done, FDS enables rapid analysis of the measured data.

The screenshot shows the FDS Data Analysis Module interface. It is divided into several sections:

- General Information:** Includes fields for 'Description of experiment', 'Material X', 'Material Y', 'Names', 'Data file', 'Unit file', and 'Result file'. Callouts point to 'User defined experimental data and units' and 'Save results to file'.
- Data Sequence:** A list of data points with columns for 'Time', 'Liquid volume', 'Pressure', 'Density', 'Liquid viscosity', and 'Slurry concentration'. Callouts point to 'User defined experimental data and units' and 'Calculated data and scale-up/sizing parameters'.
- Unit preferences:** A section for selecting units for 'Time', 'Liquid volume', 'Press dimensions', 'Pressure', 'Density', 'Liquid viscosity', and 'Slurry concentration'. Callouts point to 'User defined experimental data and units' and 'Calculated data and scale-up/sizing parameters'.
- Experimental Data:** A section for entering experimental parameters like 'Piston diameter', 'Piston press length', 'Applied pressure', 'Solids density', 'Liquid density', 'Liquid viscosity', and 'Initial slurry concentration'. Callouts point to 'Calculated data and scale-up/sizing parameters'.
- Characteristic Plot:** A graph showing 'dL/dt x 0.5 (m/m^2)' vs 'Time (s)'. Callouts point to 'Interactive graphical representation of data' and 'Display more graphs'.
- Tabulated Results:** A table of calculated parameters such as 'Specific cake resistance', 'Filter medium resistance', 'Effective feed concentration', 'Mass dry cake/filter area', 'Average cake growth rate', 'Cake solids concentration', 'Cake moisture content', 'Cake wet/dry mass ratio', 'Consolidation coefficient', 'Consolidation index', 'Final cake concentration', 'Final cake moisture content', and 'Volume solids/filter area'. Callouts point to 'Warnings showing calculated data affected, displayed when assumptions have been made due to missing input data' and 'Display meanings of warnings'.

At the bottom left, the text reads: *Example of a data analysis screen*.

After the user has entered the experimental measurements in their preferred format into FDS – FDS carries out the correct analysis. Even with well conducted tests, sometimes some of the necessary input data is missing yet the best possible analysis must be done with what information is available.

FDS deals with this situation in two ways. Firstly, when the input data are entered they are checked as far as is possible and if FDS suspects that the data may be incorrect it warns the user or does not accept the data. In many cases FDS displays a range of acceptable values for the data as a guide to what is realistic. Secondly, the calculation sequences within FDS are hierarchical. Depending on which data are missing, a sequence of assumptions are made in order to carry out the calculation. After an assumption has been made, a warning may appear against item(s) of output data on the results screen.

Key features of the Data Analysis Module include:

- Analysis of constant pressure filtration test data
- Analysis of jar test sedimentation data
- Analysis of piston press or consolidation data
- Checking of input data to protect against possible incorrect data entry
- Interactive graphical presentation of data to enable the user to input interpretations of the measured data
- Output data in graphical or tabulated format
- All data required for process design, simulation and scale-up (and much more) are output
- Data from several analyses can be compared and correlated.

SIMULATION MODULES

Two simulation models are available – the *Vacuum Filter Simulation Module* and the *Pressure Filter Simulation Module*. These provide the calculation sequences for 10 types of vacuum filters and 11 types of pressure filters.

The screenshot shows the software interface for filter simulation, divided into several sections:

- General Information:** Includes fields for Notes, Names, Config file, Pump curve file, Unit file, Wash curve files, and Result file.
- Cycle Configuration:** Allows defining phases (e.g., Filtration, Wash, Gas deliquor) and unit preferences (Density, Viscosity, Surface tension, etc.).
- Simulation Data:** Contains parameters for Filter, Suspension, and Phase 1, such as Drum diameter, Drum width, Area fraction, and Filter medium resistance.
- Schematic mass balance:** A flow diagram showing the separator and the flow of Feed, Wash, Cake, Filtrate, and Washings, with associated mass and solute values.
- Graphical Results:** A plot of Cumulative volume of liquid vs Angle, showing the volume of liquid (m³) versus the angle around the filter (degrees).

Callouts highlight the following features:

- User defined cycle configuration and units:** Points to the Cycle Configuration and Unit Preferences sections.
- User defined feed suspension and filter cycle data:** Points to the Simulation Data section.
- Save results to file:** Points to the Result file field.
- Mass balance from the simulation for each component in the feed and wash:** Points to the Schematic mass balance diagram.
- Graphical representation of all calculated data for the filter cycle:** Points to the Graphical Results plot.
- Tabulated representation of calculated data:** Points to the 'Show table' button.

Example of filter simulation results screen

The first step in a simulation is to gather and input the necessary data. This requires the filter cycle – the combination of the cake formation, cake washing and cake deliquoring stages – to be defined. FDS allows for more than one washing or deliquoring in a cycle. Each stage requires its own sets of input data – which can be in the units preferred by the user.

Key features of the Simulation Modules include:

- Input of process data for the feed suspension, filter cake and filter type
- Prevention of impractical stages on particular designs of filters – (such as cake washing on a rotary disc filter)
- Simulation of different modes of cake formation (in practice this depends on the type/method of pumping the feed to the filter) – constant pressure, constant flow and variable pressure/variable flow
- Simulation of compression filtration
- Simulation of cake post-treatment processes (cake washing and cake deliquoring)
- Options to over-ride default washing and deliquoring models with experimentally measured data
- Checking of input data for its reasonableness (FDS offers a range of numerical values for the data to guide the user as to what is realistic)
- Where possible the simulation calculation sequences within FDS are hierarchical - depending on which data are missing, a sequence of assumptions are made in order to carry out the calculation
- FDS takes account of practical constraints (for example, the minimum cake thickness that can be discharged from the particular filter design) that affect the operation of the filter type
- Graphical or tabulated output of results
- On screen display of a process mass balance, indicating the input/output amounts of the solid, the liquid, and the dissolved component that is monitored during cake washing
- Results from the simulation can be saved on disk for later recall and viewing in spreadsheets.

COMPUTER REQUIREMENTS and UPDATES

FDS is supplied as a CD and will run on a PC operating under Windows 98, 2000, NT or XP. FDS requires 75 MB of hard disk space. Software updates will be available free of charge periodically on www.filtrationsolutions.co.uk

ORDER FORM

To: Filtration Solutions, 5 Henry Dane Way, Newbold Coleorton, Leicestershire, LE67 8PP, UK. (Fax: +44 (0)1530 223124 email: filtrationsolutions@ntlworld.com)

Please supply the following:

| | Number of copies | Price per copy | Total |
|--|---------------------|-------------------|-------|
| Selection module and equipment catalogue | | £450 | |
| Data analysis module | | £150 | |
| Vacuum filter simulation module | | £350 | |
| Pressure filter simulation module | | £350 | |
| TOTAL | | | |

All prices are in Pounds Sterling and include postage and packing.

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