TFS 500
Virtual Program Language
v 1.2
1. Table of Contents

1. TABLE OF CONTENTS ................................ ..........................................................2
2. DOCUMENT HISTORY ................................ .....................................................3
3. GENERAL ..............................................................................................................4
4. INSTRUCTION SET ................................ ...........................................................5
   4.1 GENERAL .......................................................................................................5
   4.2 INSTRUCTIONS ............................................................................................6
   4.3 INSTRUCTION STRUCTURE IN THE PLC ..................................................11
5. COMPONENTS .......................................................................................................12
   5.1 GENERAL .....................................................................................................12
   5.2 VALVES ..........................................................................................................12
   5.3 TEMPERATURE SET VALUES .......................................................................13
   5.4 TEMPERATURE ACTUAL VALUES ..............................................................13
   5.5 FLOW SET VALUES .......................................................................................14
   5.6 FLOW ACTUAL VALUES ...............................................................................14
   5.7 PRESSURE ACTUAL VALUES ......................................................................14
   5.8 USER COMMANDS ......................................................................................14
   5.9 PUMP COMMANDS .....................................................................................14
6. LOGICAL OPERATORS .........................................................................................15
7. MESSAGES ...........................................................................................................15
8. EXAMPLES .........................................................................................................16
   8.1 STARTUP-ROUTINE ......................................................................................16
   8.2 SHUTDOWN-ROUTINE ..................................................................................17
   8.3 MAJOR-ROUTINE .........................................................................................19
   8.4 FATAL-ROUTINE ..........................................................................................20
   8.5 EMERGENCY-ROUTINE ..............................................................................21
   8.6 PRESSURIZE-ROUTINE ...............................................................................22
   8.7 VACUUMIZE-ROUTINE ...............................................................................24
   8.8 AL2O3 120 NM-RECIPE ..............................................................................26
2. Document History

<table>
<thead>
<tr>
<th>Date</th>
<th>Author</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>23.12.2005</td>
<td>PRa</td>
<td>V1.0 First version</td>
</tr>
<tr>
<td>04.05.2006</td>
<td>PRa</td>
<td>V1.1 Some modifications for the project</td>
</tr>
<tr>
<td>07.09.2007</td>
<td>PRa</td>
<td>V1.2 Minor changes for components etc.</td>
</tr>
</tbody>
</table>
3. General

TFS 500 control system is based on:

- PC user interface (PC or HMI=Human Machine Interface), which is implemented using InTouch-software. Operator can control and monitor operation of TFS 500 by using PC.
- Siemens S7-300 PLC (PLC), which takes care of measuring encoders (temperature etc. process values) and controlling actuators (valves etc.).

Operation of TFS 500 can be configured by using Virtual Program Language (VPL). VPL-programs acts as recipes for operation of TFS 500. VPL has defined instruction set and format, which is explained in this document. VPL-programs are written by using text editor like Windows Notepad. File must not include any control characters, it has to be pure ASCII-file.

There are some definition files in C:\Project\Recipe\Config-directory. Do not change the files except Message.txt!

Available instructions are defined in Command.txt-file. See Chapter 4. Instruction Set.

Available components are defined in Component.txt-file. See Chapter 5. Components.

Available logical operators are defined in Operator.txt-file. See Chapter 6. Logical Operators.

Available messages are defined in Message.txt-file. See Chapter 7. Messages.

There are some example routine and recipe files in this document, too. See Chapter 8. Examples.

Time value can be between 10ms - 23h59min59s990ms. Hours are defined by “h”, minutes by “min”, seconds by “s” and milliseconds by “ms” and they have to follow right after numeric value. Following expressions are valid; 1h, 5min10s, 5s200ms and 300 ms. Following expressions are invalid; 1200ms (milliseconds greater than 990ms), 5min100ms (no second field at all) and 1h6s (no minute field at all).

Recipes have to be saved in C:\Project\Recipe\User Recipe -directory of the PC. File name has to be New Recipe.txt. See HMI Operating Instruction for further information how to take it into use.

Routines have to be saved in C:\Project\Recipe\Routine –directory as Startup.txt, Shutdown.txt, Major.txt, Fatal.txt, Emergency.txt, Pressurize.txt and Vacuumize.txt.

VPL-program syntax has to be checked before downloading it to the PLC. PLC acts as a VPL-interpreter.

Recipes and routines can include comments. If first character in a line is “*” –character, then it is compiled as a comment. Otherwise it is compiled as a command line.
4. Instruction Set

General

There are about 20 instructions, which can be used to control the operation of TFS 500. Instructions have been divided into sub-categories:

- Valve control instructions:
  - OPEN, CLOSE for opening and closing valves (max. 5 at same time).
  - PULSE, PULSESPECIAL for pulsing valves (max. 5 at same time).
  - PURGE for waiting some time before controlling next valve.

- Temperature and flow control instructions:
  - TEMP for setting set values for temperature (chiller, hot sources, chamber).
  - FLOW for setting set value for flow (mass flow controllers).

- HMI control instructions:
  - WRITE for writing messages for user.

- Program structure instructions:
  - REPEAT, REND for making repeat loops (normally used when pulsing the valves).
  - WTIME for making a delay.
  - WUNTIL for waiting comparison to be true (normally used to compare actual and set value, max. 5 at same time).
  - WUSER for waiting user response (normally used together with WRITE-instruction).
  - CALL, SFUNC, EFUNC for making functions in a recipe.
  - SPROG, EPROG for starting and ending a program.

- Other instructions:
  - PUMP for starting and stopping a vacuum pump.
Instructions

Valve control instructions (1-10)

OPEN (Inst=1)
Operands:
• Max. 5 valve symbols separated by a comma without spaces.
Parameters:
• None.
Example:
• OPEN DV-PG1,DV-PG2

CLOSE (Inst=2)
Operands:
• Max. 5 valve symbols separated by a comma without spaces.
Parameters:
• None.
Example:
• CLOSE DV-PG1,DV-PG2

PULSE (Inst=3)
Operands:
• Max. 5 valve symbols separated by a comma without spaces.
Parameters:
• Pulse Time [see time format in Chapter 3. General].
Example:
• PULSE DV-PG1,DV-PG2 500ms

PULSESPECIAL (Inst=4)
Operands:
• Max. 5 valve symbols, equal sign (‘=’) and valve status separated by a comma without spaces.
Parameters:
• Pulse Time [see time format in Chapter 3. General].
Example:
• PULSESPECIAL DV-PG1=1,DV-PG2=0 500ms
PURGE (Inst=5)
Operands:
  • None.
Parameters:
  • Wait time [see time format in Chapter 3. General].
Example:
  • PURGE 5s100ms

Temperature and flow control instructions (11-20)

TEMP (Inst=11)
Operands:
  • Temperature set value symbol.
Parameters:
  • Temperature set value [C].
Example:
  • TEMP TIAC-R1S=200

FLOW (Inst=12)
Operands:
  • Flow set value symbol.
Parameters:
  • Flow set value [sccm].
Example:
  • FLOW MFC-AS=350

HMI control instructions (31-40)

WRITE (Inst =31)
Operands:
  • Message symbol.
Parameters:
  • None.
Example:
  • WRITE M3
Program structure instructions (41-50)

REPEAT (Inst=41)
Operands:
• None.
Parameters:
• Repeat value.
Example:
• REPEAT 200

REND (Inst=42)
Operands:
• None.
Parameters:
• None.
Example:
• REND

WTIME (Inst=43)
Operands:
• None.
Parameters:
• Wait time [see time format in Chapter 3 General].
Example:
• WTIME 5s100ms

WUNTIL (Inst=44)
Operands:
• Max. 5 combinations, where can be temperature set and actual value symbols, flow set and actual value symbols, pressure set and actual value symbols and constants. Individual comparison is separated by a logical operator (<=, <, >=, >, =). Comparisons are separated by a comma without spaces.
Parameters:
• Timeout time [see time format in Chapter 3 General].
Example:
• WUNTIL TIAC-R1<=TIAC-R1S,PIA-P1<PIA-FB 50s
Note:
• Logical operator between comparisons is always AND.
• Constants in comparisons have to be less or equal than 2000.
• After timeout comes up a popup window for user response (Yes or Force to idle).
CALL (Inst=45)
Operands:
  • Function number (1-99), underscore ('_') and function description.
Parameters:
  • None.
Example:
    • CALL F1_OPENVALVE
Note:
  • Function name has to always start with Fxx_, where xx is numeric value 1-99.

SPROG (Inst=46)
Operands:
  • None.
Parameters:
  • None.
Example:
    • SPROG

EPROG (Inst=47)
Operands:
  • None.
Parameters:
  • None.
Example:
    • EPROG

SFUNC (Inst=48)
Operands:
  • Function number (1-99), underscore ('_') and function description.
Parameters:
  • None.
Example:
    • SFUNC F1_OPENVALVE
Note:
  • Function name has to always start with Fxx_, where xx is numeric value 1-99.
EFUNC (Inst=49)
Operands:
  • Function number (1-99), underscore (‘_’) and function description.
Parameters:
  • None.
Example:
  • EFUNC F1_OPENVALVE
Note:
  • Function name has to always start with Fxx_, where xx is numeric value 1-99.

WUSER (Inst=50)
Operands:
  • User command symbol.
Parameters:
  • None.
Example:
  • WUSER START

Other instructions (61-70)

PUMP (Inst=61)
Operands:
  • Pump command symbol.
Parameters:
  • None.
Example:
  • PUMP START, PUMP STOP (no other alternatives).
## Instruction Structure in the PLC

<table>
<thead>
<tr>
<th>Field</th>
<th>Data type</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cmd[x].Inst</td>
<td>INT</td>
<td>1=OPEN, 2=CLOSE,…,61=PUMP</td>
</tr>
<tr>
<td>Cmd[x].Oper[1].Oper1</td>
<td>INT</td>
<td>1st operand set, PLC code</td>
</tr>
<tr>
<td>Cmd[x].Oper[1].Oper2</td>
<td>INT</td>
<td>1st operand set, PLC code for logical operator</td>
</tr>
<tr>
<td>Cmd[x].Oper[1].Oper3</td>
<td>INT</td>
<td>1st operand set, PLC code</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cmd[x].Oper[5].Oper1</td>
<td>INT</td>
<td>5th operand set (like 1st)</td>
</tr>
<tr>
<td>Cmd[x].Oper[5].Oper2</td>
<td>INT</td>
<td>5th operand set (like 1st)</td>
</tr>
<tr>
<td>Cmd[x].Oper[5].Oper3</td>
<td>INT</td>
<td>5th operand set (like 1st)</td>
</tr>
<tr>
<td>Cmd[x].Par1</td>
<td>REAL</td>
<td>Command parameter 1, can be e.g. Set Value</td>
</tr>
<tr>
<td>Cmd[x].Par2</td>
<td>DINT</td>
<td>Command parameter 2, can be e.g. Pulse Time, Wait Time, Timeout Time, Repeat Value</td>
</tr>
</tbody>
</table>

**Note!**
Recipe consist of up to 200 commands (x=1-200).

Routines (Startup, Shutdown, Major, Fatal, Emergency, Pressurize and Vacuumize) consist of up to 40 commands (x=1-200).
5. Components

General

These definitions are in Component.txt-file. Symbols for valves, set and actual values, user commands and pump commands are set to PLC codes, which are used for controlling corresponding component in the PLC.

### Valves

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>A</th>
<th>PLC code</th>
</tr>
</thead>
<tbody>
<tr>
<td>DV-PG1</td>
<td>Gas source 1 pulsing valve</td>
<td>A8.0</td>
<td>1001</td>
</tr>
<tr>
<td>DV-PG2</td>
<td>Gas source 2 pulsing valve</td>
<td>A8.1</td>
<td>1002</td>
</tr>
<tr>
<td>DV-PG3</td>
<td>Gas source 3 pulsing valve</td>
<td>A8.2</td>
<td>1003</td>
</tr>
<tr>
<td>DV-PG4</td>
<td>Gas source 4 pulsing valve</td>
<td>A8.3</td>
<td>1004</td>
</tr>
<tr>
<td>DV-PL1</td>
<td>Liquid source 1 pulsing valve</td>
<td>A8.4</td>
<td>1005</td>
</tr>
<tr>
<td>DV-BL1</td>
<td>Liquid source 1 bubbler valve</td>
<td>A8.5</td>
<td>1006</td>
</tr>
<tr>
<td>DV-PL2</td>
<td>Liquid source 2 pulsing valve</td>
<td>A8.6</td>
<td>1007</td>
</tr>
<tr>
<td>DV-BL2</td>
<td>Liquid source 2 bubbler tube valve</td>
<td>A8.7</td>
<td>1008</td>
</tr>
<tr>
<td>DV-PL3</td>
<td>Liquid source 3 pulsing valve</td>
<td>A9.0</td>
<td>1009</td>
</tr>
<tr>
<td>DV-BL3</td>
<td>Liquid source 3 bubbler tube valve</td>
<td>A9.1</td>
<td>1010</td>
</tr>
<tr>
<td>DV-PL4</td>
<td>Liquid source 4 pulsing valve</td>
<td>A9.2</td>
<td>1011</td>
</tr>
<tr>
<td>DV-BL4</td>
<td>Liquid source 4 bubbler tube valve</td>
<td>A9.3</td>
<td>1012</td>
</tr>
<tr>
<td>DV-BHA1</td>
<td>Hot source 1 bubbler valve</td>
<td>A9.4</td>
<td>1013</td>
</tr>
<tr>
<td>DV-BHA2</td>
<td>Hot source 2 bubbler valve</td>
<td>A9.5</td>
<td>1014</td>
</tr>
<tr>
<td>DV-N01</td>
<td>N2 inlet main valve (Note! 0=zero)</td>
<td>A9.6</td>
<td>1015</td>
</tr>
<tr>
<td>DV-NV1</td>
<td>Vacuum chamber flow valve</td>
<td>A9.7</td>
<td>1016</td>
</tr>
<tr>
<td>DV-NLL1</td>
<td>Load lock chamber flow valve</td>
<td>A10.0</td>
<td>1017</td>
</tr>
<tr>
<td>DV-NP1</td>
<td>Pump gas ballast valve</td>
<td>A10.1</td>
<td>1018</td>
</tr>
<tr>
<td>DV-VP1</td>
<td>Vacuum pump main valve</td>
<td>A10.2</td>
<td>1019</td>
</tr>
<tr>
<td>DV-VP2</td>
<td>Vacuum pump soft start valve</td>
<td>A10.3</td>
<td>1020</td>
</tr>
<tr>
<td>DV-VP3</td>
<td>Vacuum pump valve for cool down</td>
<td>A10.4</td>
<td>1021</td>
</tr>
<tr>
<td>DV-VV1</td>
<td>Vacuum chamber pump down valve</td>
<td>A10.5</td>
<td>1022</td>
</tr>
<tr>
<td>DV-VLL1</td>
<td>Load lock pump down valve</td>
<td>A10.6</td>
<td>1023</td>
</tr>
<tr>
<td>DV-VLL2</td>
<td>Load lock pump soft start valve</td>
<td>A10.7</td>
<td>1024</td>
</tr>
<tr>
<td>AV-WV</td>
<td>Water inlet valve for circulation 1</td>
<td>A11.0</td>
<td>1025</td>
</tr>
<tr>
<td>AV-WH</td>
<td>Water inlet valve for circulation 2</td>
<td>A11.1</td>
<td>1026</td>
</tr>
<tr>
<td>DV-PH1</td>
<td>Hot liquid source pulsing valve</td>
<td>A11.2</td>
<td>1027</td>
</tr>
<tr>
<td>DV-BH1</td>
<td>Hot liquid source valve</td>
<td>A11.3</td>
<td>1028</td>
</tr>
<tr>
<td>DV-PH2</td>
<td>Hot liquid source pulsing valve</td>
<td>A11.4</td>
<td>1029</td>
</tr>
<tr>
<td>DV-BH2</td>
<td>Hot liquid source valve</td>
<td>A11.5</td>
<td>1030</td>
</tr>
<tr>
<td>DV-PA</td>
<td>Liquid source valve</td>
<td>A11.6</td>
<td>1031</td>
</tr>
<tr>
<td>DV-PB</td>
<td>Liquid source valve</td>
<td>A11.7</td>
<td>1032</td>
</tr>
</tbody>
</table>
### Temperature set values

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>PQW/Q</th>
<th>PLC code</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIAC-LS</td>
<td>Chiller temperature</td>
<td>PQW256</td>
<td>2001</td>
</tr>
<tr>
<td>TIAC-H11S</td>
<td>Hot source #1.1 temperature</td>
<td>Q0.6</td>
<td>2002</td>
</tr>
<tr>
<td>TIAC-H12S</td>
<td>Hot source #2.2 temperature</td>
<td>Q0.7</td>
<td>2003</td>
</tr>
<tr>
<td>TIAC-H21S</td>
<td>Hot source #2.1 temperature</td>
<td>Q1.0</td>
<td>2004</td>
</tr>
<tr>
<td>TIAC-H22S</td>
<td>Hot source #2.2 temperature</td>
<td>Q1.1</td>
<td>2005</td>
</tr>
<tr>
<td>TIAC-R1S</td>
<td>Reactor chamber temperature</td>
<td>Q0.0-Q0.5</td>
<td>2006</td>
</tr>
<tr>
<td>TIAC-S1S</td>
<td>Spare heating 1</td>
<td></td>
<td>2007</td>
</tr>
<tr>
<td>TIAC-S2S</td>
<td>Spare heating 2</td>
<td></td>
<td>2008</td>
</tr>
<tr>
<td>TIAC-S3S</td>
<td>Spare heating 3</td>
<td></td>
<td>2009</td>
</tr>
<tr>
<td>TIAC-S4S</td>
<td>Spare heating 4</td>
<td></td>
<td>2010</td>
</tr>
</tbody>
</table>

### Temperature actual values

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>PIW</th>
<th>PLC code</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIAC-R1</td>
<td>Reactor chamber temperature (control)</td>
<td>PIW316</td>
<td>2201</td>
</tr>
<tr>
<td>TIA-R1</td>
<td>Reactor chamber temperature (monitoring)</td>
<td>PIW318</td>
<td>2202</td>
</tr>
<tr>
<td>TIAC-H1</td>
<td>PT100 spare</td>
<td>PIW260</td>
<td>2203</td>
</tr>
<tr>
<td>TIAC-H2</td>
<td>PT100 spare</td>
<td>PIW262</td>
<td>2204</td>
</tr>
<tr>
<td>TIAC-H3</td>
<td>PT100 spare</td>
<td>PIW264</td>
<td>2205</td>
</tr>
<tr>
<td>TIA-S1</td>
<td>PT100 spare</td>
<td>PIW266</td>
<td>2206</td>
</tr>
<tr>
<td>TIA-S2</td>
<td>PT100 spare</td>
<td>PIW268</td>
<td>2207</td>
</tr>
<tr>
<td>TIA-S3</td>
<td>PT100 spare</td>
<td>PIW270</td>
<td>2208</td>
</tr>
<tr>
<td>TIAC-V1H</td>
<td>Chamber operation door resistor temperature</td>
<td>PIW272</td>
<td>2209</td>
</tr>
<tr>
<td>TIAC-V2H</td>
<td>Chamber back wall resistor temperature</td>
<td>PIW274</td>
<td>2210</td>
</tr>
<tr>
<td>TIAC-V3H</td>
<td>Chamber cylinder #1 resistor temperature</td>
<td>PIW276</td>
<td>2211</td>
</tr>
<tr>
<td>TIAC-V4H</td>
<td>Chamber cylinder #2 resistor temperature</td>
<td>PIW278</td>
<td>2212</td>
</tr>
<tr>
<td>TIAC-V5H</td>
<td>Chamber cylinder #3 resistor temperature</td>
<td>PIW280</td>
<td>2213</td>
</tr>
<tr>
<td>TIAC-V6H</td>
<td>Chamber cylinder #4 resistor temperature</td>
<td>PIW282</td>
<td>2214</td>
</tr>
<tr>
<td>TIAC-H1H</td>
<td>Hot source #1.1 resistor temperature</td>
<td>PIW284</td>
<td>2215</td>
</tr>
<tr>
<td>TIAC-H2H</td>
<td>Hot source #1.2 resistor temperature</td>
<td>PIW286</td>
<td>2216</td>
</tr>
<tr>
<td>TIAC-H3H</td>
<td>Hot source #1.3 resistor temperature</td>
<td>PIW288</td>
<td>2217</td>
</tr>
<tr>
<td>TIAC-H4H</td>
<td>Hot source #1.4 resistor temperature</td>
<td>PIW290</td>
<td>2218</td>
</tr>
<tr>
<td>TIA-V1</td>
<td>Vessel wall temperature</td>
<td>PIW292</td>
<td>2219</td>
</tr>
<tr>
<td>TIA-S5</td>
<td>Thermocouple spare</td>
<td>PIW294</td>
<td>2220</td>
</tr>
<tr>
<td>TIAC-L</td>
<td>Chiller temperature (monitoring)</td>
<td>PIW310</td>
<td>2221</td>
</tr>
<tr>
<td>TIA-S6</td>
<td>Spare</td>
<td>PIW312</td>
<td>2222</td>
</tr>
<tr>
<td>TIA-S7</td>
<td>Spare</td>
<td>PIW314</td>
<td>2223</td>
</tr>
<tr>
<td>TIA-S8</td>
<td>Spare</td>
<td>PIW256</td>
<td>2224</td>
</tr>
<tr>
<td>TIA-S9</td>
<td>Spare</td>
<td>PIW258</td>
<td>2225</td>
</tr>
</tbody>
</table>
## Flow set values

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>PQW</th>
<th>PLC code</th>
</tr>
</thead>
<tbody>
<tr>
<td>MFC-AS</td>
<td>Flow A</td>
<td>PQW258</td>
<td>3001</td>
</tr>
<tr>
<td>MFC-BS</td>
<td>Flow B</td>
<td>PQW260</td>
<td>3002</td>
</tr>
<tr>
<td>MFC-VS</td>
<td>Flow V</td>
<td>PQW262</td>
<td>3003</td>
</tr>
</tbody>
</table>

## Flow actual values

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>PIW</th>
<th>PLC code</th>
</tr>
</thead>
<tbody>
<tr>
<td>MFC-A</td>
<td>Flow A (monitoring)</td>
<td>PIW304</td>
<td>3201</td>
</tr>
<tr>
<td>MFC-B</td>
<td>Flow B (monitoring)</td>
<td>PIW306</td>
<td>3202</td>
</tr>
<tr>
<td>MFC-V</td>
<td>Flow V (monitoring)</td>
<td>PIW308</td>
<td>3203</td>
</tr>
</tbody>
</table>

## Pressure actual values

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>PIW</th>
<th>PLC code</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIA-V1</td>
<td>Chamber pressure (monitoring)</td>
<td>PIW296</td>
<td>4201</td>
</tr>
<tr>
<td>PIA-FA</td>
<td>Feeding pressure A (monitoring)</td>
<td>PIW298</td>
<td>4202</td>
</tr>
<tr>
<td>PIA-P1</td>
<td>Reactor pressure (monitoring)</td>
<td>PIW300</td>
<td>4203</td>
</tr>
<tr>
<td>PIA-FB</td>
<td>Feeding pressure B (monitoring)</td>
<td>PIW302</td>
<td>4204</td>
</tr>
</tbody>
</table>

## User commands

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>M</th>
<th>PLC code</th>
</tr>
</thead>
<tbody>
<tr>
<td>START</td>
<td>User start command</td>
<td>M30.0</td>
<td>5001</td>
</tr>
<tr>
<td>STOP</td>
<td>User stop command</td>
<td>M30.1</td>
<td>5002</td>
</tr>
<tr>
<td>YES</td>
<td>User yes command</td>
<td>M30.2</td>
<td>5003</td>
</tr>
<tr>
<td>NO</td>
<td>User no command</td>
<td>M30.3</td>
<td>5004</td>
</tr>
<tr>
<td>CMD5</td>
<td>User command 5</td>
<td>M30.4</td>
<td>5005</td>
</tr>
<tr>
<td>CMD6</td>
<td>User command 6</td>
<td>M30.5</td>
<td>5006</td>
</tr>
<tr>
<td>CMD7</td>
<td>User command 7</td>
<td>M30.6</td>
<td>5007</td>
</tr>
<tr>
<td>CMD8</td>
<td>User command 8</td>
<td>M30.7</td>
<td>5008</td>
</tr>
</tbody>
</table>

## Pump commands

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>M</th>
<th>PLC code</th>
</tr>
</thead>
<tbody>
<tr>
<td>START</td>
<td>User start command (=1)</td>
<td>M50.2</td>
<td>6001</td>
</tr>
<tr>
<td>STOP</td>
<td>User stop command (=0)</td>
<td>M50.2</td>
<td>6002</td>
</tr>
</tbody>
</table>
6. Logical operators

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Operator</th>
<th>PLC code</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=</td>
<td>&lt;=</td>
<td>1</td>
</tr>
<tr>
<td>&lt;</td>
<td>&lt;</td>
<td>2</td>
</tr>
<tr>
<td>&gt;=</td>
<td>&gt;=</td>
<td>3</td>
</tr>
<tr>
<td>&gt;</td>
<td>&gt;</td>
<td>4</td>
</tr>
<tr>
<td>=</td>
<td>=</td>
<td>5</td>
</tr>
</tbody>
</table>

7. Messages

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Message</th>
<th>PLC code</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>Message text 1</td>
<td>1</td>
</tr>
<tr>
<td>M2</td>
<td>Message text 2</td>
<td>2</td>
</tr>
<tr>
<td>M3</td>
<td>Message text 3</td>
<td>3</td>
</tr>
<tr>
<td>M4</td>
<td>Message text 4</td>
<td>4</td>
</tr>
<tr>
<td>M5</td>
<td>Message text 5</td>
<td>5</td>
</tr>
<tr>
<td>M6</td>
<td>Message text 6</td>
<td>6</td>
</tr>
<tr>
<td>M7</td>
<td>Message text 7</td>
<td>7</td>
</tr>
<tr>
<td>M8</td>
<td>Message text 8</td>
<td>8</td>
</tr>
<tr>
<td>M9</td>
<td>No text → empty line</td>
<td>9</td>
</tr>
<tr>
<td>M10</td>
<td>Status text 2</td>
<td>10</td>
</tr>
<tr>
<td>M11</td>
<td>Status text 3</td>
<td>11</td>
</tr>
<tr>
<td>M12</td>
<td>Status text 4</td>
<td>12</td>
</tr>
<tr>
<td>M13</td>
<td>Status text 5</td>
<td>13</td>
</tr>
<tr>
<td>M14</td>
<td>Status text 6</td>
<td>14</td>
</tr>
<tr>
<td>M15</td>
<td>Status text 7</td>
<td>15</td>
</tr>
<tr>
<td>M16</td>
<td>Status text 8</td>
<td>16</td>
</tr>
<tr>
<td>M17</td>
<td>Status text 9</td>
<td>17</td>
</tr>
<tr>
<td>M18</td>
<td>Status text 10</td>
<td>18</td>
</tr>
<tr>
<td>M19</td>
<td>Status text 11</td>
<td>19</td>
</tr>
<tr>
<td>M20</td>
<td>Status text 12</td>
<td>20</td>
</tr>
</tbody>
</table>

There are two kinds of messages:

- M1-M8: Requires user response. Used together with WUSER-command.

If machine is in Major-, Fatal- or Emergency-state, then messages are shown in red colour.

Messages in the PC may differ from above shown message texts.
8. Examples

Startup-routine

*Routine STARTUP
*Mim 02.05.2006
*Routine for preparing the STARTUP-state

SPROG

*Close pulse valves
CLOSE DV-PL1,DV-BL1,DV-PL4,DV-BL4
CLOSE DV-PG1,DV-PG2,DV-PG3
CLOSE DV-PL2,DV-BL2,DV-PL3,DV-BL3
CLOSE DV-PA,DV-PB

*Close hot source valves
CLOSE DV-BH1,DV-BH2

*Open the N2 main valves
OPEN DV-N01,DV-NV1

*Set flows
FLOW MFC-AS=100
FLOW MFC-BS=100
FLOW MFC-VS=200

WRITE M9

EPROG
Shutdown-routine

*Routine SHUTDOWN
*mim 02.05.2006
*Routine for safely shutting down the machine

SPROG

*Close pulse valves
CLOSE DV-PL1,DV-BL1,DV-PL4,DV-BL4
CLOSE DV-PG1,DV-PG2,DV-PG3
CLOSE DV-PL2,DV-BL2,DV-PL3,DV-BL3
CLOSE DV-PA,DV-PB

*Close hot source valves
CLOSE DV-BH1,DV-BH2

*Open soft start valve
OPEN DV-VP2
CLOSE DV-VP1,DV-VP3

*Stop heating or set shutdown temperatures
TEMP TIAC-R1S=10
TEMP TIAC-H1S=10
TEMP TIAC-H2S=10

*Open nitrogen valves
OPEN DV-N01,DV-NV1

*Set the MFC flows
*MFC-A and MFC-B has high enough flow levels to ensure inert gas valving, even if hot
*sources are used.
FLOW MFC-AS=200
FLOW MFC-BS=200
FLOW MFC-VS=200

*Check vacuum level
WRITE M13
WUNTIL PIA-V1<900 30s

*Check that vacuum level is sufficient
WUNTIL PIA-V1<100 30min

*Wait until hot sources are safely cooled to prevent vaporization contamination
WRITE M12
WUNTIL TIAC-H1<50,TIAC-H2<50 5h

WRITE M9

*Set the MFC-V flow to pressurize the vacuum chamber.
FLOW MFC-VS=10000

*Close vacuum valves
CLOSE DV-VP1,DV-VP2,DV-VP3

*Wait until desired vacuum level has been achieved
WUNTIL PIA-V1>100 15min

*Stop the nitrogen flows
FLOW MFC-AS=0
FLOW MFC-BS=0
FLOW MFC-VS=0
CLOSE DV-N01,DV-NV1

*Use gas ballast to purge the vacuum pump
OPEN DV-NP1

WTIME 15min

CLOSE DV-NP1

*Reactor is now under vacuum, about 100 mbar. All gas flows are stopped, but the vacuum pump is running.
*Heating of reactor and hot sources are off. Hot sources are cooled.

EPROG
Major-routine

*Routine MAJOR
*SSn 5.12.2005
*Routine for reacting to Major alarms

SPROG
*Machine is ready for STARTUP routine
EPROG
Fatal-routine

*Routine FATAL
*Mim 02.05.2006
*Routine for FATAL alarm

SPROG

*Close pulse valves
CLOSE DV-PL1,DV-BL1,DV-PL4,DV-BL4
CLOSE DV-PG1,DV-PG2,DV-PG3
CLOSE DV-PL2,DV-BL2,DV-PL3,DV-BL3
CLOSE DV-PA,DV-PB

*Close hot source valves
CLOSE DV-BH1,DV-BH2

*Close vacuum valves
CLOSE DV-VP1,DV-VP2,DV-VP3

*Close nitrogen valves
CLOSE DV-N01,DV-NV1

*Stop heating
TEMP TIAC-R1S=10
TEMP TIAC-H1S=10
TEMP TIAC-H2S=10

*Stop the flows
FLOW MFC-AS=0
FLOW MFC-BS=0
FLOW MFC-VS=0

*Window for user
WRITE M1
WUSER YES

EPROG
Emergency-routine

*Routine EMERGENCY
*Mim 02.05.2006
*Routine for reacting to Emergency stop

SPROG

*Close pulse valves
CLOSE DV-PL1,DV-BL1,DV-PL4,DV-BL4
CLOSE DV-PG1,DV-PG2,DV-PG3
CLOSE DV-PL2,DV-BL2,DV-PL3,DV-BL3
CLOSE DV-PA,DV-PB

*Close hot source valves
CLOSE DV-BH1,DV-BH2

*Close vacuum valves
CLOSE DV-VP1,DV-VP2,DV-VP3

*Close nitrogen valves
CLOSE DV-N01,DV-NV1

*Stop heating
TEMP TIAC-R1S=10
TEMP TIAC-H1S=10
TEMP TIAC-H2S=10

*Stop the flows
FLOW MFC-AS=0
FLOW MFC-BS=0
FLOW MFC-VS=0

*Window for user
WRITE M1
WUSER YES

EPROG
Pressurize-routine

*Routine PRESSURIZE
*PSo 27.02.2006
*Routine for pressurizing the vacuum chamber

SPROG

*Close pulse valves
CLOSE DV-PL1,DV-BL1,DV-PL4,DV-BL4
CLOSE DV-PG1,DV-PG2,DV-PG3
CLOSE DV-PL2,DV-BL2,DV-PL3,DV-BL3
CLOSE DV-PA,DV-PB

*Close hot source valves
CLOSE DV-BH1,DV-BH2

*Ensure that temperatures are not too high
*WUNTIL TIAC-R1<=100 1s

*Prepare the vacuum valves for pressurizing
CLOSE DV-VP1,DV-VP2

*Open small flow into pump line
OPEN DV-VP3

* Prepare pressurizing by opening the conduct between the vacuum and the reaction chambers
OPEN DV-VV1

*Open the N2 main valves
OPEN DV-N01,DV-NV1

*Fill the vacuum chamber
FLOW MFC-AS=500
FLOW MFC-BS=500
FLOW MFC-VS=20000

WRITE M14
WUNTIL PIA-V1>=990 30min

CLOSE DV-VP3
FLOW MFC-AS=100
FLOW MFC-BS=100
FLOW MFC-VS=1000
WRITE M9
EPROG
Vacuumize-routine

*Routine Vacuumize
*Mim 02.05.2006
*Routine for preparing the VACUUMIZE-state

SPROG

*Close pulse valves
CLOSE DV-PL1,DV-BL1,DV-PL4,DV-BL4
CLOSE DV-PG1,DV-PG2,DV-PG3
CLOSE DV-PL2,DV-BL2,DV-PL3,DV-BL3
CLOSE DV-PA,DV-PB

*Close hot source valves
CLOSE DV-BH1,DV-BH2

*Open chamber vacuum valve
OPEN DV-VV1

WRITE M8
WUSER YES

*Open reactor soft start valve
OPEN DV-VP2

*Check vacuum level
WUNTIL PIA-V1<900 30s

*Open the N2 main valves
OPEN DV-N01,DV-NV1

*Set flows
FLOW MFC-AS=100
FLOW MFC-BS=100
FLOW MFC-VS=200

*Define the right time for opening the main valve
WUNTIL PIA-V1<100 10min

*Open the main valve and close the soft start valve
OPEN DV-VP1
CLOSE DV-VP2,DV-VP3

*Ensure that the reactor can reach the processing pressure
*WUNTIL PIA-P1<10 10min
*Prepare the process on by closing the conduit between the vacuum chamber and the reaction chamber
CLOSE DV-VV1

WRITE M9
EPROG
Al2O3 120 nm-recipe

*Recipe Al2O3 120nm
*Recipe for 120nm Al2O3
*Precursors TMA and Water by own vapor pressures
*Mim 25.4.2006, Preinstalled program
*Based on flow chart N500053
*TMA at liquid source 3
*Water at liquid source 1
*Source needle valves (NV-PL1 open 1/2 turn, NV-PL3 open 1 turn)
*Inert gas drain valves (NV-IA open 1 turn, NV-IB open 1/4 turn)
*Chiller temperature 20C
*2mm spacer ring
*Water pulse without DV-PA, only by own vapour pressure
*Total cycle time 2s

*Program start
SPROG

*Open the N2 main valves
OPEN DV-N01, DV-NV1

*Set flows
FLOW MFC-AS=200
FLOW MFC-BS=100
FLOW MFC-VS=2000

*Close pulse valves
CLOSE DV-PL1, DV-BL1, DV-PL4, DV-BL4
CLOSE DV-PG1, DV-PG2, DV-PG3, DV-PG4
CLOSE DV-PL2, DV-BL2, DV-PL3, DV-BL3
CLOSE DV-PA, DV-PB

*Close hot source valves
CLOSE DV-BH1, DV-BH2

*Check the vacuum level
WUNTIL PIA-P1<10 30s

*Set temperatures
   TEMP TIAC-R1S=220
   TEMP TIAC-LS=20
*wait until temperature is ok
   WUNTIL TIAC-R1>=TIAC-R1S 5h

*Are temperatures ok to start the process?
WRITE M5
WUSER YES

WTIME 1s

*open precursor hand valves
WRITE M6
WUSER YES

*Pulsing TMA and Water 1100 cycles, appr. 120 nm
REPEAT 1100

   OPEN DV-PB
   WTIME 250ms
   Pulse DV-PL3 250ms
   WTIME 250ms
   CLOSE DV-PB
   Purge 500ms

   Pulse DV-PL1 250ms
   Purge 500ms

REND

WRITE M9

*Set temperatures
   TEMP TIAC-R1S=20
*   TEMP TIAC-LS=20

*Close pulse valves
CLOSE DV-PL1,DV-BL1,DV-PL4,DV-BL4
CLOSE DV-PG1,DV-PG2,DV-PG3,DV-PG4
CLOSE DV-PL2,DV-BL2,DV-PL3,DV-BL3
CLOSE DV-PA,DV-PB

*Close hot source valves
CLOSE DV-BH1,DV-BH2

*Use gas ballast 1 min
*PULSE DV-NP1 1min

*close precursor hand valves
WRITE M7
WUSER YES

*end program
EPROG