

Neutral Exchange Format for Battery Test Sequences (NEXFTS)

Exchanging test programs without errors or worries

Dr. Torsten Hildebrandt

Manager Requirements Analysis

2026-04-30



Neutral Exchange Format for Battery Test Sequences

What is NEXFTS

NEXFTS is a YAML-based format for the complete description of battery test sequences

- defines all test steps (discharge, charge, rest phases, loops, jumps)
- machine-readable
- human-readable
- Basis for official documentation in international standards
- Basis for automated generation of Device-specific test implementation by converter scripts
- Replaces error-prone manual transcription from tables in international standards
- Ensures that test procedures can be carried out correctly and in accordance with standards
- Enables the release of official versions via an open-source platform, such as GitHub

Table 3 – PPC at Beginning Of Life (BOL) – Categories 1, 2 and 3

Structure	no.	Step	T / °C	t	U / V	I / A	Description
PPC (BOL)	01	PP1 or PP2	25				Table 9 or Table 10 – PPC Procedure Option PP2 at specified temperature in column T/°C, 100% SOC
	02	DCH	25	4 h	> 10,5	I_n	Discharge by 20% of C_n in 4 h
	03	PAU	25	Min 8 h Max 48 h			relaxation at specified temperature in column T/°C before cooling
	04	PAU	-18	Min 24 h Max 48 h			soak at specified temperature in column T/°C
	05	PP1 or PP2	-18				Table 9 or Table 10 at specified temperature in column T/°C, partial state of charge
	06	PAU	25	Min 16 h Max 48 h			soak at specified temperature in column T/°C
	07	DCH	25	6 h	> 10,5	I_n	Discharge by a total of 50% of C_n in 10 h
	08	PAU	25	Min 8 h Max 48 h			relaxation at specified temperature in column T/°C before cooling
	09	PAU	-18	Min 24 h Max 48 h			soak at specified temperature in column T/°C
	10	PP1 or PP2	-18				Table 9 or Table 10 at specified temperature in column T/°C, partial state of charge

Key:
PP1 Pulse Profile PP1 according to Table 9
PP2 PPC Procedure Option PP2 according to Table 10
SOC State Of Charge
 C_n Nominal capacity
 I_n Nominal 20 hour discharge current



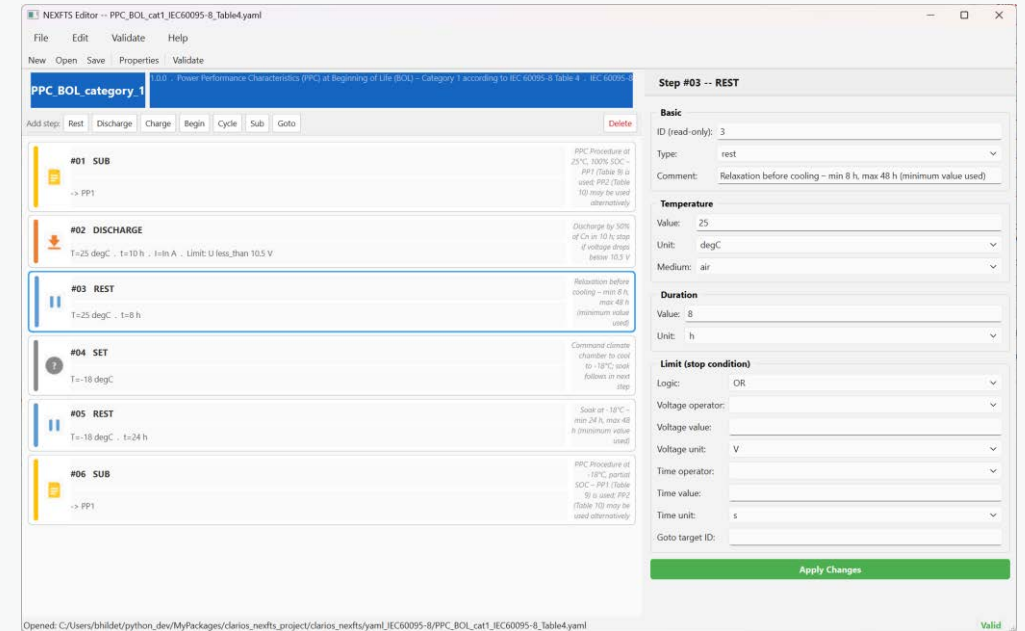
Neutral Exchange Format for Battery Test Sequences



Where can I get the YAML files, or how can I create them?

NEXFTS YAML-files

- can be written manually as they are just text files
- can be setup using the NEXFTS Editor by drag and drop the required test steps
- can be easily shared with others as they are just text files
- can be validated using an available schema file to ensure correct syntax
- can be converted to device specific data formats (Digatron-Converter available)



Outlook

- Set-up repository for test procedures of International and European Standards

Wednesday 15:00 – 16:30

CENELEC Workshop on NEXFTS
exchange format & data evaluation

Neutral Exchange Format for Battery Test Sequences

Language elements

Step types

Type	Description	Required fields
rest	Rest phase	id, type, temperature, duration
discharge	Discharge	id, type, temperature, current, duration, limit
charge	Charge	id, type, temperature, voltage, current, duration, limit
begin	Start of a loop	id, type, level, comment
cycle	End of a loop	id, type, level, count
sub	Subroutine call	id, type, name
goto	Unconditional jump to a step	id, type, target_id
set	Set temperature	id, type, temperature, wait

Attributes of Step types

Attribute	Description	Used in Step type
comment	Free-text description	all
temperature	Test temperature setpoint	rest, discharge, charge, set
duration	Fixed run time of the step	rest, discharge, charge
current	Discharge or maximum charge current	discharge, charge
voltage	Charge voltage setpoint	charge
limit	Abort / cut-off condition(s)	discharge, charge
result	Measurement values to be recorded	discharge, charge, rest
level	Loop nesting depth	begin, cycle
count	Number of loop iterations	cycle
name	Name of the subroutine to call	sub
target_id	ID of the jump target step	goto
wait	Pause until temperature setpoint is reached	set

Neutral Exchange Format for Battery Test Sequences

Example

nexfts_schema_version: "0.1.1"

metadata:

name: "PPC_BOL_categories_1_2_3"
version: "1.0.0"
description: "Power Performance Characteristics (PPC) at
Beginning of Life (BOL) – Categories 1, 2 and 3
according to IEC 60095-8 Table 3"
standard:
name: "IEC 60095-8"
title: "Lead-acid starter batteries – Part 8: Batteries for
micro-cycle applications"
date: "2025-01"
clause: "Table 3"

steps:

Step 01 – PP1 or PP2 at 25°C, 100% SOC
- id: 1
type: sub
name: "PP1"
comment: "PPC Procedure at 25°C, 100% SOC – PP1 (Table 9) is
used; PP2 (Table 10) may be used alternatively"

Step 02 – DCH at 25°C, 4 h – discharge by 20% Cn

- id: 2
type: discharge
temperature:
value: 25
unit: "degC"
medium: "air"
current:
value: "In"
unit: "A"
duration:
value: 4
unit: "h"
limit:
voltage:
operator: less_than
value: 10.5
unit: "V"
comment: "Discharge by 20% of Cn in 4 h; stop if voltage
drops below 10.5 V,,

Step 03 – PAU at 25°C, min 8 h max 48 h – relaxation before cooling

- id: 3
type: rest
temperature:
value: 25
unit: "degC"
medium: "air"
duration:
value: 8
unit: "h"
comment: "Relaxation before cooling – min 8 h, max 48 h
(minimum value used)"

Neutral Exchange Format for Battery Test Sequences

Data evaluation beyond Excel

NEXFTS might be extended to formalize the result data structures as well:

- Enable interchangeability of result data sets
- Usage structured data formats like YAML, JASON or HDF5
- Basis for
 - Plots
 - Reports
 - Validation and compliance checks
 - and further automated data processing
- Implementation via Python using DataClasses



CENELEC Workshop NEXFTS

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Key:
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Neutral Exchange Format for Battery Test Sequences

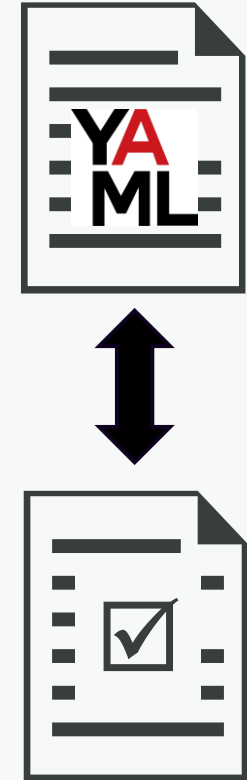
File formats

NEXFTS uses YAML files for test descriptions

- A YAML file is a human-readable text file used to store structured data (YAML stands for: YAML Ain't Markup Language)
- Readable: uses indentation instead of brackets
- Hierarchical: represents nested data
- Minimal syntax: easy to write and review

NEXFTS comes with a schema-file

- A schema file defines the rules and structure that a YAML file must follow.
- It is describing what fields are allowed, their types, and constraints
- It is used to validate the syntax of the NEXFTS-YAML file.
- It uses JSON (JavaScript Object Notation) for rules definition
- It ensures NEXFTS-Files without formal errors



Neutral Exchange Format for Battery Test Sequences

Main structure of NEXFTS

A NEXFTS test definition is a YAML file that completely describes a battery test. It consists of five mandatory sections:

Section	Description
nexfts_schema_version	Schema version against which the file is validated
metadata	Name, version and description of the test
global_values	Global variables (e.g. rated current, rated capacity)
global_limits	Global safety limits
steps	Sequence of test steps (at least 1)

Neutral Exchange Format for Battery Test Sequences



Main structure of NEXFTS - metadata

Describes the test and optionally contains a standards reference.

Field	Type	Required	Description
name	string	☒	Unique name of the test
version	string	☒	Version of the test definition
description	string	☒	Short description of the test
standard	object	☐	Standards reference
standard.name	string	☒ (if standard)	Standard identifier, e.g. "EN 50342-1"
standard.title	string	☐	Full title of the standard
standard.date	string	☐	Publication date, e.g. "2015-04"
standard.clause	string	☐	Referenced clause, e.g. "Clause 9.1"

```
metadata:
  name: "cranking_performance_EN"
  version: "1.0.0"
  description: "Cranking performance test according to
               EN 50342-1"
  standard:
    name: "EN 50342-1"
    title: "Lead-acid starter batteries - General
           requirements and methods of test"
    date: "2015-04"
    clause: "Clause 9.1"
```

Neutral Exchange Format for Battery Test Sequences

Main structure of NEXFTS - global_values

Defines named variables that can be referenced in step expressions (e.g. "Icc", "0.6 * Icc").

Field	Type	Required	Allowed values
value	number	✓	Any number
unit	string	✓	"A", "V", "Ah"
description	string	□	Free text

```
global_values:
  Cn:
    value: 100
    unit: "Ah"
    description: "Nominal capacity"
  Icc:
    value: 680
    unit: "A"
    description: "Cold cranking current (EN 50342-1)"
  Uc:
    value: 14.4
    unit: "V"
    description: "Charge voltage"
  In:
    value: 5
    unit: "A"
    description: "Nominal current (Cn / 20h)"
```

Neutral Exchange Format for Battery Test Sequences

Main structure of NEXFTS - *global_limits*

Defines global safety limits for the entire test.

Field	Type	Required	Allowed units
max_voltage	object	✓	"V", "mV"
max_current	object	✓	"A", "mA"
max_temperature	object	✓	"degC"

```
global_limits:
  max_voltage:
    value: 16.5
    unit: "V"
  max_current:
    value: 300
    unit: "A"
  max_temperature:
    value: 60
    unit: "degC"
```

Each object has the required fields value (number) and unit (string).

Neutral Exchange Format for Battery Test Sequences

Main structure of NEXFTS - steps

Sequence of test steps, at least one step is required.
Every step has at minimum the required fields id and type.

Field	Type	Required	Description
id	integer	✓	Unique step ID
type	object	✓	Step type

```
steps:
- id: 1
  type: rest
  temperature:
    value: 25
    unit: "degC"
    medium: "air"
  duration:
    value: 24
    unit: "hours"
  comment: "Initial rest at 25°C"
```

Further required fields depend on the step type.

Neutral Exchange Format for Battery Test Sequences

NEXFTS Step-definitions

Step types

Type	Description	Required fields
rest	Rest phase	id, type, temperature, duration
discharge	Discharge	id, type, temperature, current, duration, limit
charge	Charge	id, type, temperature, voltage, current, duration, limit
begin	Start of a loop	id, type, level, comment
cycle	End of a loop	id, type, level, count
sub	Subroutine call	id, type, name
goto	Unconditional jump to a step	id, type, target_id
set	Set temperature	id, type, temperature, wait

Attributes of Step types

Attribute	Description	Used in Step type
comment	Free-text description	all
temperature	Test temperature setpoint	rest, discharge, charge, set
duration	Fixed run time of the step	rest, discharge, charge
current	Discharge or maximum charge current	discharge, charge
voltage	Charge voltage setpoint	charge
limit	Abort / cut-off condition(s)	discharge, charge
result	Measurement values to be recorded	discharge, charge, rest
level	Loop nesting depth	begin, cycle
count	Number of loop iterations	cycle
name	Name of the subroutine to call	sub
target_id	ID of the jump target step	goto
wait	Pause until temperature setpoint is reached	set

Neutral Exchange Format for Battery Test Sequences

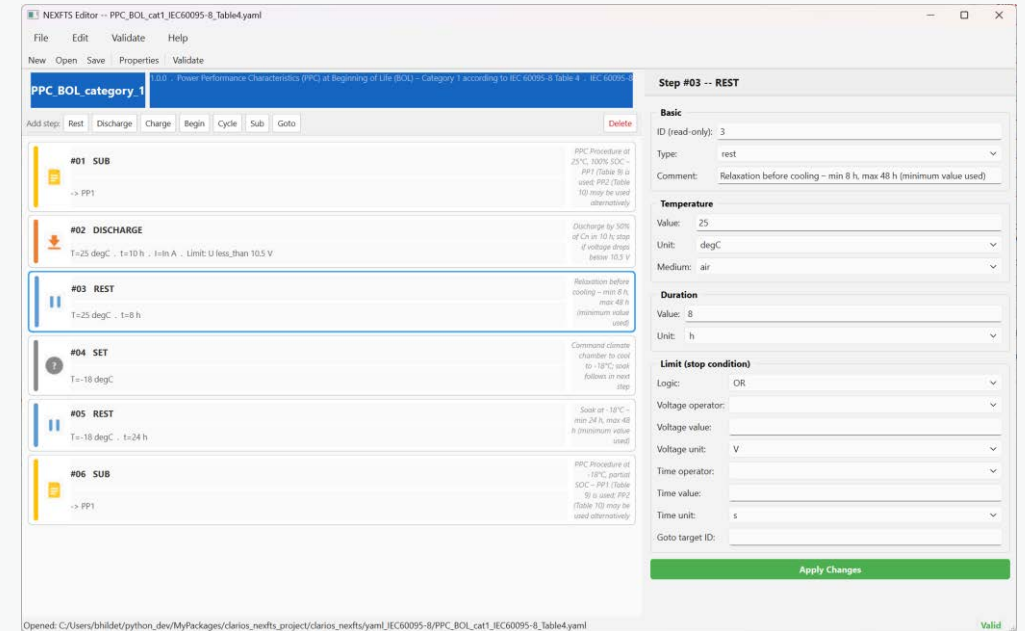
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Outlook

- Set-up repository for test procedures of International and European Standards



Neutral Exchange Format for Battery Test Sequences

What can I do with a NEXFTS-File

Available NEXFTS Tools

- NEXFTS to Markdown
 - Convert a NEXFTS definition to a human friendly table to be used in technical documentation, papers or standards
- NEXFTS to Digatron
 - Converts a NEXFTS definition into a text-file that can be pasted into Digatron Battery manager
- NEXFTS Validation
 - Validation routine for formal check of syntax against NEXFTS schema
 - Reports any deviations

Neutral Exchange Format for Battery Test Sequences

NEXFTS Validation

```
Eingabeaufforderung
>nexfts_validate.exe -h
usage: nexfts-validate [-h] [-s SCHEMA] [-q] [--json] FILE [FILE ...]

Validate one or more NEXFTS YAML files against the JSON Schema.

Exit code 0 = all valid, 1 = validation error(s), 2 = usage/IO error.

positional arguments:
  FILE                NEXFTS YAML file(s) to validate

options:
  -h, --help            show this help message and exit
  -s, --schema SCHEMA  Path to nexfts.schema.json (default: bundled schema)
  -q, --quiet           Only print OK / FAIL per file, no detailed error list
  --json               Output errors as JSON (for CI / tooling)

>nexfts_validate.exe -s nexfts.schema.json coldcrank_EN.yaml
[OK] coldcrank_EN.yaml is valid against nexfts.schema.json

>nexfts_validate.exe -s nexfts.schema.json coldcrank_EN_issue01.yaml
[FAIL] coldcrank_EN_issue01.yaml violates schema nexfts.schema.json

01. coldcrank_EN_issue01.yaml:46:5
  Path:    steps[id=1].type
  Error:    'pau' is not one of ['rest', 'discharge', 'charge', 'begin', 'cycle', 'sub', 'goto', 'set']
  Hint:    invalid value 'pau' - allowed: ['rest', 'discharge', 'charge', 'begin', 'cycle', 'sub', 'goto', 'set']
  Rule:    enum = ['rest', 'discharge', 'charge', 'begin', 'cycle', 'sub', 'goto', 'set']

>
```

Neutral Exchange Format for Battery Test Sequences

CLARIOS

NEXFTS to Markdown

Eingabeaufforderung

```
>nexfts_to_markdown.exe -h
usage: nexfts-to-markdown [-h] (-y FILE | --batch DIR) [-o PATH]

Generate Markdown documentation from a NEXFTS YAML test sequence.
Table layout:
  No. | Step | T / °C | t | U / V | I / A | Limit | Description | Result

Single-file mode (-y):  prints to stdout if no -o is given.
Batch mode (--batch):   converts all *.yaml files in a directory.

options:
  -h, --help                show this help message and exit
  -y, --yaml FILE           Single NEXFTS YAML input file
  --batch DIR               Directory - convert every *.yaml file found inside
  -o, --output PATH         Output .md file (single) or output directory (batch). Single-file without -o: output goes
                           without -o: each .md is written next to its .yaml file.

Examples:
  nexfts-to-markdown -y input.yaml
  nexfts-to-markdown -y input.yaml -o output.md
  nexfts-to-markdown --batch yaml_IEC60095-8/ -o doc/

>
```

Cranking performance test according to EN 50342-1

Source: cranking_performance_EN.yaml
Standard: EN 50342-1, Clause 9.1
YAML version: 1.0.0 - Last modified: 2026-05-15 12:37
Format: NEXFTS (Neutral Exchange Format for Battery Test Sequences), schema version 0.1.1
Generated by: nexfts_to_markdown.py - 2026-05-15 16:46

Global Values

symbol	value	unit	description
Cn	100	Ah	Nominal capacity
Icc	680	A	Cold cranking current (EN 50342-1)
Uc	14.4	V	Charge voltage
In	5	A	Nominal current (Cn / 20h)

Global Safety Limits

parameter	value	unit
max_voltage	16.5	V
max_current	300	A
max_temperature	60	degC

Test Sequence

No.	Step	T / °C	t	U / V	I / A	Limit	Description	Result
1	rest	25	24 h				Initial rest at 25°C	
2	set	-18 °C					Set climate chamber to -18°C	
3	rest	-18	24 h				Temperature soak at -18 degC (cooling phase)	
4	discharge	-18	10 s	< 9.5 V	680 A	< 9.5 V	First discharge step at -18 degC	
5	rest	-18	10 s				Rest after first discharge step	
6	discharge	-18	180 s	< 6 V	408 A	< 6 V	Second discharge step at -18 degC	
7	set	25 °C					Set water bath to 25°C	
8	charge	25	24 h	14.4 V	25 A		Final charge at 25 degC	

Notes (Resolved Expressions)

Step 4: $I_{cc} = 680 = 680\text{ A (I / A)}$
Step 6: $0.6 * I_{cc} = 0.6 * 680 = 408\text{ A (I / A)}$
Step 8: $U_c = 14.4 = 14.4\text{ V (U / V)}$; $5 * I_n = 5 * 5 = 25\text{ A (I / A)}$

Neutral Exchange Format for Battery Test Sequences

NEXFTS to Digatron

```
Eingabeaufforderung
>nexfts_to_digatron.exe -h
usage: nexfts-to-digatron [-h] -y YAML [-o OUTPUT] [-l {DE,EN}] [-c]

Convert a NEXFTS YAML file to Digatron format.

Always writes BOTH files from the -o base path:
<stem>.md   Markdown table (documentation)
<stem>.txt  Digatron skill file (tab-delimited, importable)

Omit -o to print the Markdown to stdout (dry-run, no files written).

options:
  -h, --help            show this help message and exit
  -y, --yaml YAML       NEXFTS YAML input file
  -o, --output OUTPUT   Output base path (extension is ignored); writes <path>.md and <path>.txt. If omitted, Markdown is printed
                        to stdout (dry-run, no files written).
  -l, --language {DE,EN}
                        Digatron operator language: DE (default) or EN
  -c, --clipboard        Copy the skill-file text directly to the Windows clipboard (12-column format, CF_UNICODETEXT). Paste
                        immediately into the Digatron BM system with Ctrl+V. Requires pywin32 (pip install pywin32). Can be
                        combined with -o.

Examples:
nexfts-to-digatron -y input.yaml
nexfts-to-digatron -y input.yaml -o output_base
nexfts-to-digatron -y input.yaml -o output_base -l EN
nexfts-to-digatron -y input.yaml -c

>
```

Step	Label	Operator	Nominal Value	Limit	Action	Registration
1		PAU		24 h		
2		SET	SetT = -18			
3		PAU		24 h		
4		DCH	680 A	10 sec		
				< 9.5 V		
5		PAU		10 sec		
6		DCH	408 A	180 sec		
				< 6 V		
7		SET	SetT = 25			
8		CHA	14.4 V	24 h		
			25 A			

Neutral Exchange Format for Battery Test Sequences

Development Status – Next steps

Current development status

- First NEXFTS language definition with Schema-File
- Demonstrator of graphical NEXFTS Editor
- Set of example files available (IEC 60095-8)
- First conversion scripts available
- github repository available to download schema and examples
 - [github - NEXFTS_Definitions](#)

Next needed steps

- Assessment of whether the concept is helpful and useful enough to be continued
- Identification of project members
- Definition of work packages
- Validation / double check of concept

Neutral Exchange Format for Battery Test Sequences

Example

```
nexfts_schema_version: "0.1.1"
```

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             according to IEC 60095-8 Table 3"
standard:
  name: "IEC 60095-8"
  title: "Lead-acid starter batteries – Part 8: Batteries for
         micro-cycle applications"
  date: "2025-01"
  clause: "Table 3"
```

steps:

```
# Step 01 – PP1 or PP2 at 25°C, 100% SOC
- id: 1
  type: sub
  name: "PP1"
  comment: "PPC Procedure at 25°C, 100% SOC – PP1 (Table 9) is
           used; PP2 (Table 10) may be used alternatively"
```

```
# Step 02 – DCH at 25°C, 4 h – discharge by 20% Cn
```

```
- id: 2
  type: discharge
  temperature:
    value: 25
    unit: "degC"
    medium: "air"
  current:
    value: "In"
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    value: 4
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  limit:
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      unit: "V"
  comment: "Discharge by 20% of Cn in 4 h; stop if voltage
           drops below 10.5 V,,
```

```
# Step 03 – PAU at 25°C, min 8 h max 48 h – relaxation before cooling
```

```
- id: 3
  type: rest
  temperature:
    value: 25
    unit: "degC"
    medium: "air"
  duration:
    value: 8
    unit: "h"
  comment: "Relaxation before cooling – min 8 h, max 48 h
           (minimum value used)"
```

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