TOP-X

HIGH FREQUENCY X-RAY GENERATORS

MODEL: TOP-X 100NR

SERVICE MANUAL

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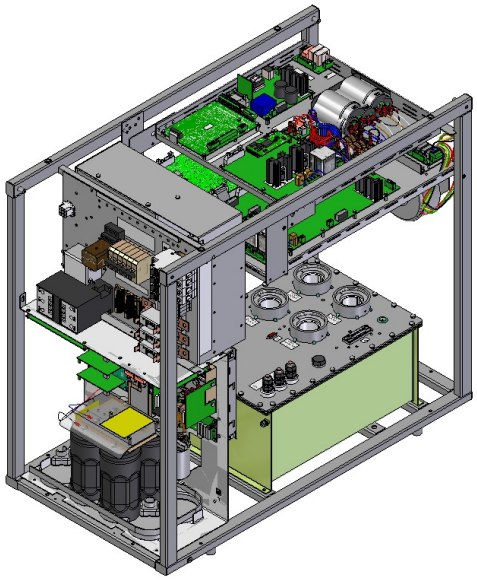


REVISION HISTORY

Revision code	*Date of release*	*List of changes (chapter no)*
G	22.08.2008	• New high voltage tank HFHVT5: **2.1**, **2.3.4**, **2.4.1** (NRTUS), **2.4.4** • Changed description of NRRAD replacement, new description for NRFIL replacement: **4.2.1**, **4.2.6**
F	20.12.2007	• Software upgrade to NRCON: **5.1.3**, **5.2** • Changed description for error codes: (**3.3**): **71**, **102** • New error code: **3.3.140** • NRCON also writes error to error log: **3.2.3** • New error message "language file too old": **3.2.5**
E	14.09.2007	• List of test points, test LEDs, potentiometers, DIP switches and jumpers for all boards: **2.4** • Changed description for error code: **3.3.41** • New error code: **3.3.139**
D	27.07.2007	• Collimator transformer and CSTIF are mounted in different place: **2.1**, **2.3.1**, **2.3.2**, **2.4.1**, **2.4.2**, **2.4.6** • Description for error 'Unable to turn on generator': **3.2.4** • Changed description for error codes (**3.3**): **25**, **32**, **39** • New error codes (**3.3**): **9**, **47**, **49**, **59**, **122**, **133-138** • New chapter for software upgrade: **5**
C	14.09.2006	Fluoroscopy added
B	08.03.2006	First release
A	03.02.2006	Preliminary version

TABLE OF CONTENTS

1. INTRODUCTION

This document provides instructions for troubleshooting and repairing TOP-X high frequency X-ray generator and its operator console.

This document is part of document

R-2622
TOP-X HIGH FREQUENCY GENERATORS
MODEL: TOP-X 100NR
TECHNICAL MANUAL AND INSTALLATION GUIDE

Follow all safety instructions written in *R-2622* documentation during generator setup procedures.

2. STRUCTURE OF GENERATOR

2.1 Layout of the generator and major components

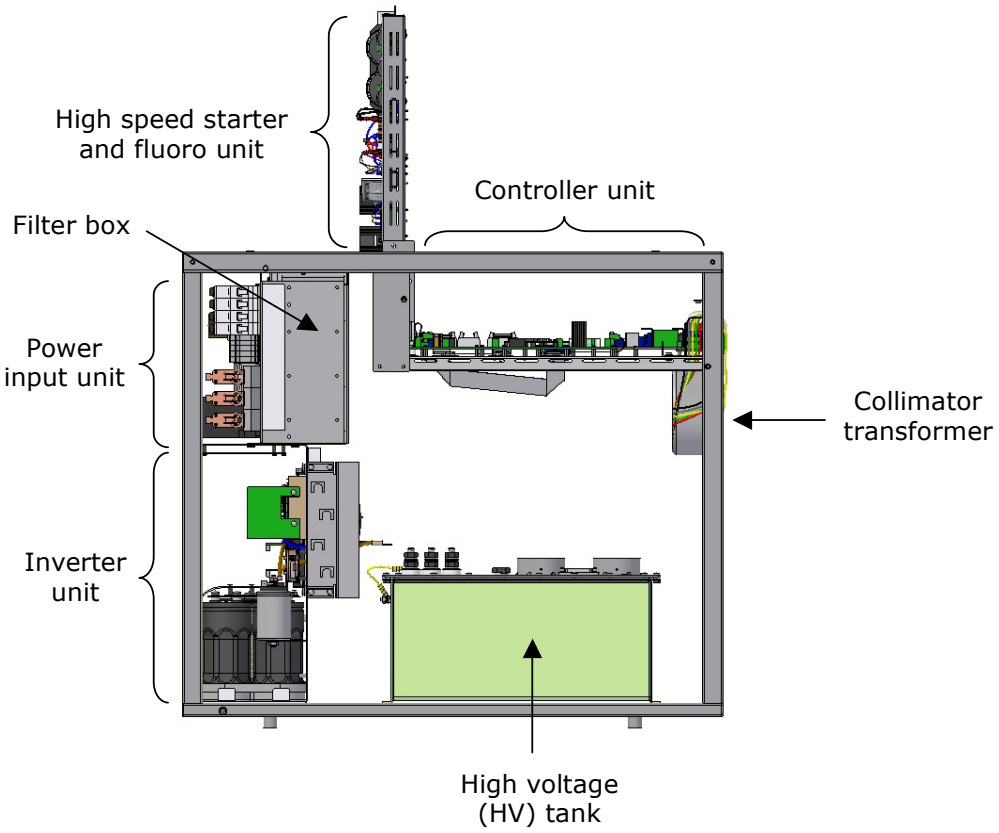
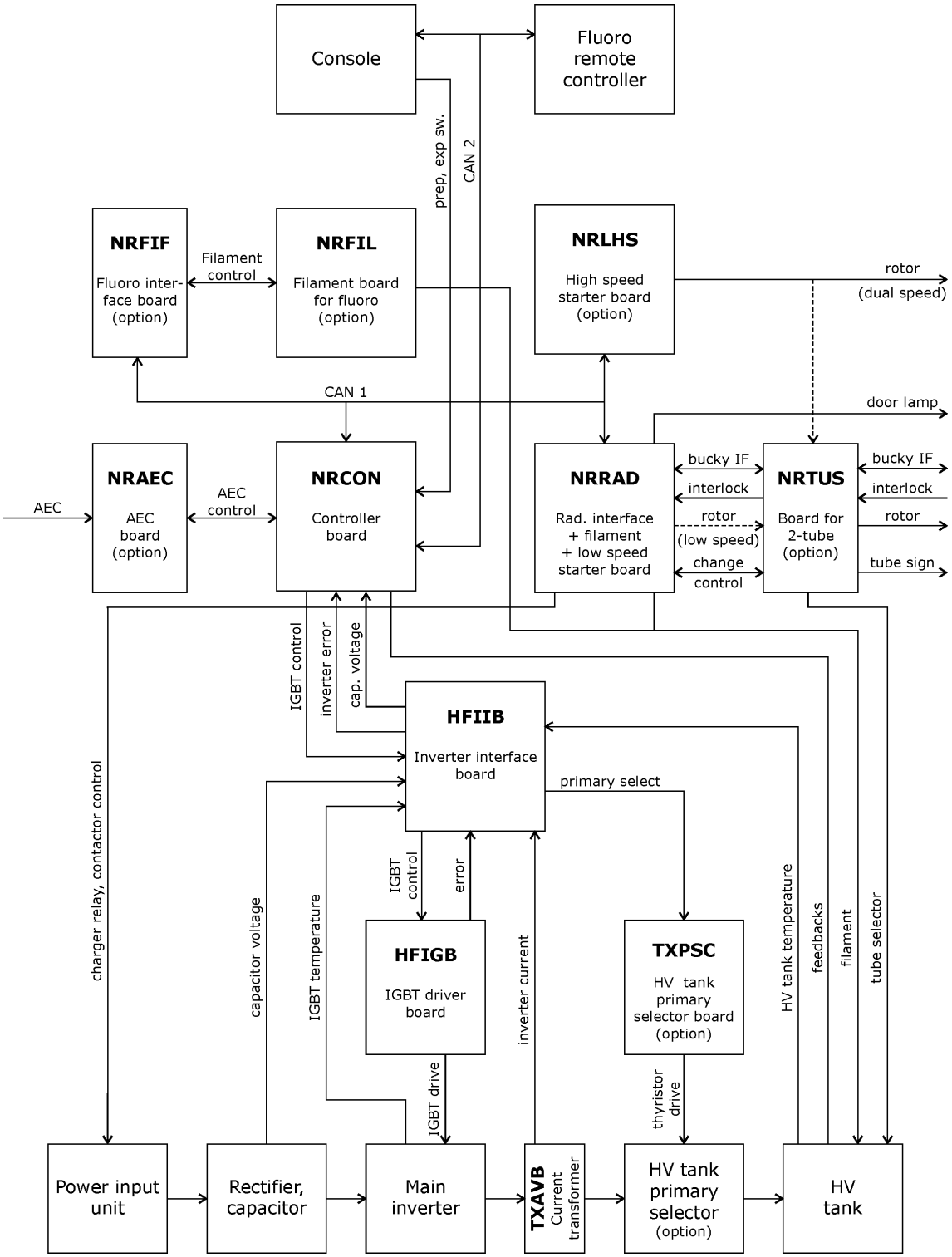


Fig. 1 Major components of generator

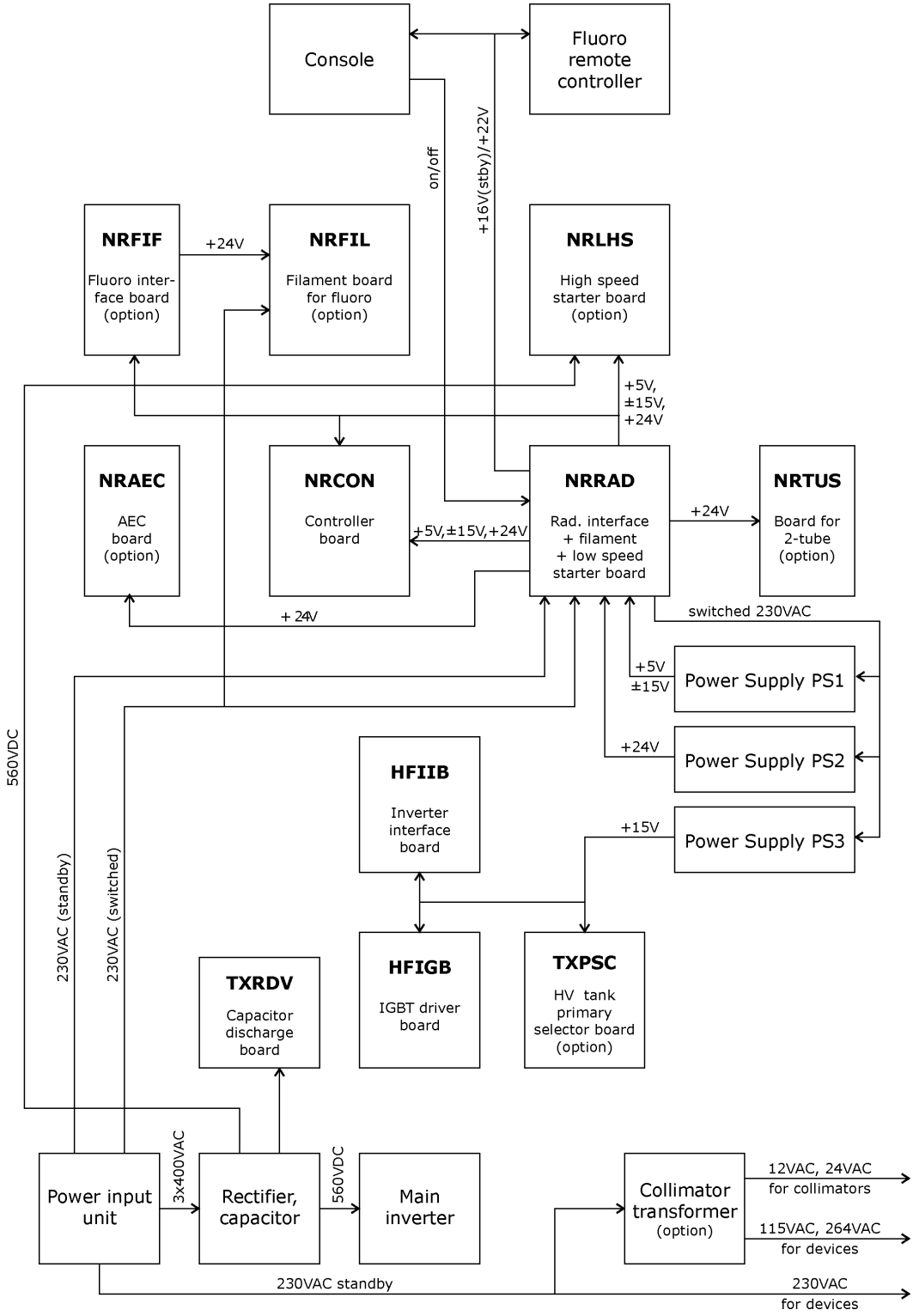
Controller unit:	Controller and interface electronics
High speed starter and fluoro unit:	Optional high (dual) speed starter and fluoro interface with second filament board
Power input unit:	Power connection, fuses, charger resistors, contactors
Inverter unit:	Capacitor bank, main inverter, HV tank primary selector (optional, it depends on kW), inverter and selector controller electronics, capacitor discharge board
High voltage tank:	High voltage transformer, HV rectifier, filament transformer, tube selector (2-tube version only)
Filter box:	Rectifier, EMI filters
Collimator transformer:	Optional transformer for supplying collimator lamps

2.2 Electrical block diagram

2.2.1 Main signals

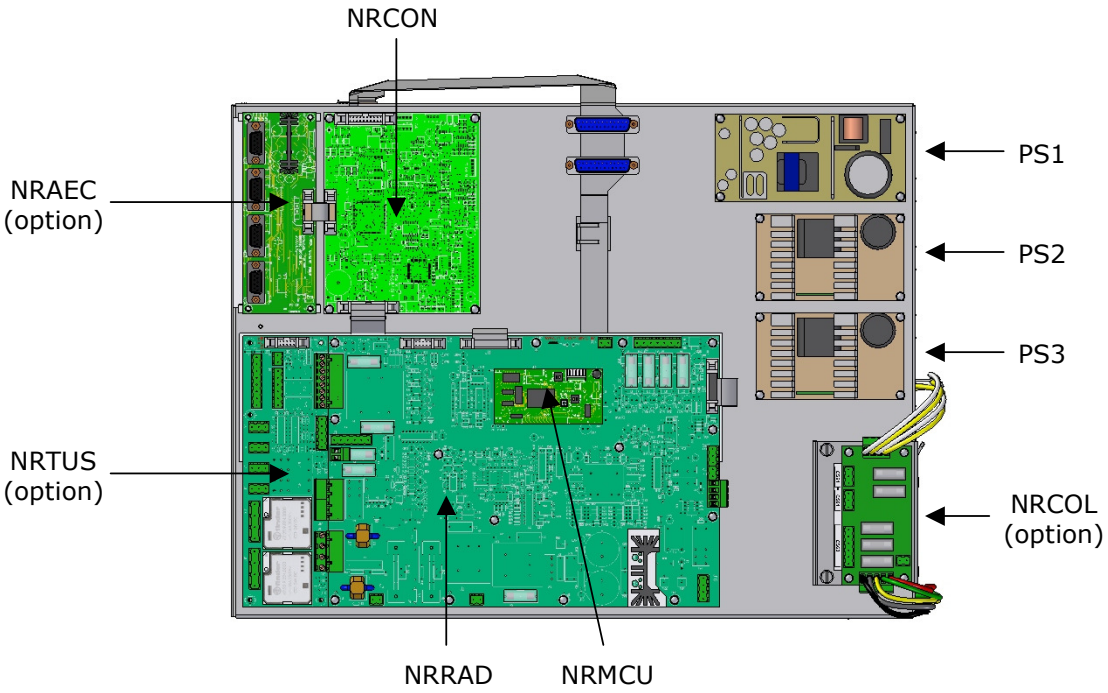


2.2.2 Power distribution

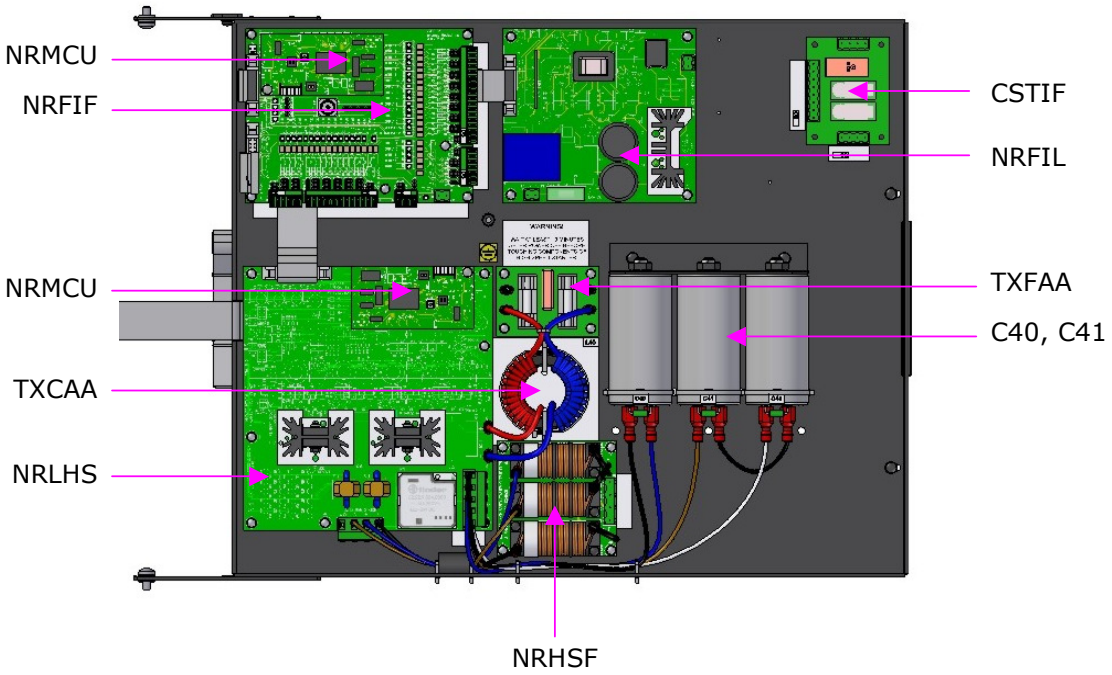


2.3 Location of boards and components

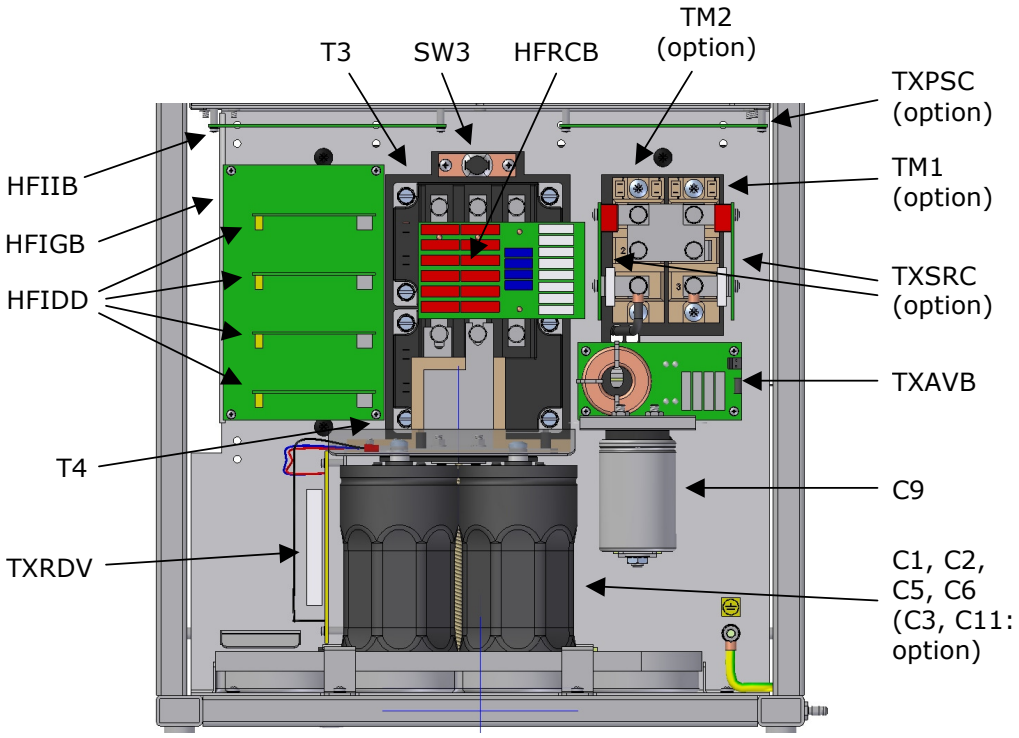
2.3.1 Controller unit



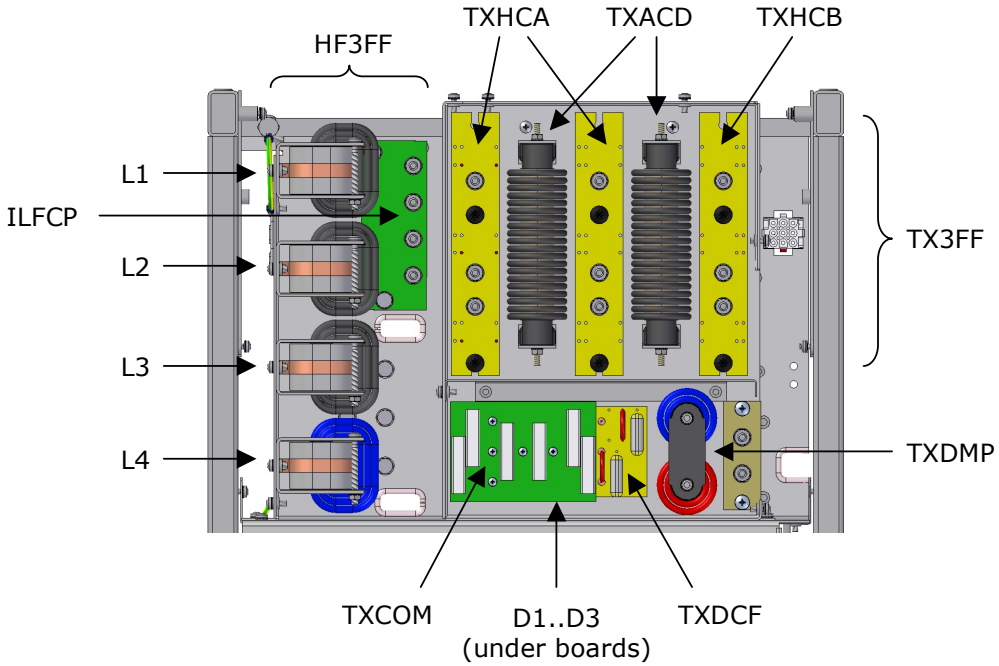
2.3.2 High speed starter and fluoro unit (option)



2.3.3 Inverter unit



2.3.4 Filter box



2.4 Functional overview

This chapter contains short functional description about the generator boards and electrical components that are marked by 5 letters (e.g. TXDMP). Main signals between boards, test points, test LEDs, potentiometers, DIP switches and jumpers are also listed.

We dedicate chapters to main components according to Fig.1. In these chapters boards/components are in alphabetical order.

2.4.1 Controller unit

Board name	*Description*
NRAEC	• AEC board with microcontroller (optional: AEC version only). • Communicates with NRCON with dedicated signals *(J1)*: *SCK/SCK3, SDATA/TXD3:* SPI bus where NRCON sends AEC parameters to NRAEC *AEC:* NRAEC pulls it to low if input level has reached the preset value during exposure *AEC0.1:* NRAEC pulls it to low if input level has reached 12.5% of the preset value during exposure (to stop exposure if there is no signal at all) • Supplies ±15V supply voltage for the chambers Test points: TP1: SDATA: serial data from NRCON, active H TP2: AEC: AEC termination, 100μs pulse, active L TP3: AEC01: AEC level 12.5% reached, active L TP4: Freq out: Digital output of selected chamber, TTL TP5: SCK: serial clock from NRCON, active H TP6: Analog out: Analog output of selected chamber, 0..4V (test point) = 0..10V (chamber) TP7: MF3: Chamber measuring field 3 (right) selected, active L TP8: MF2: Chamber measuring field 2 (left) selected, active L TP9: MF1: Chamber measuring field 1 (center) selected, active L TP10: RES: Chamber enabled, active L Test LEDs: D1: (green) +24V supply voltage OK D3: (yellow) -15V OK D4: (yellow) +15V OK D5: (yellow) -15V OK D6: (yellow) +15V OK D7: (yellow) -15V OK D8: (yellow) +15V OK D9: (yellow) -15V OK D10: (yellow) +15V OK Jumpers: JP1: AEC1 input: 1-3: digital, 2-3: analog JP2: AEC2 input: 1-3: digital, 2-3: analog JP3: AEC3 input: 1-3: digital, 2-3: analog JP4: AEC4 input: 1-3: digital, 2-3: analog JP5: PROG: open: processor programming, closed: normal use
NRCOL	Board for collimator transformer with fuses and connectors Test LEDs: LD1: +24VIF: stabilized +24VDC interface voltage is present LD2: V.OK: +12V from transformer secondary 1 OK

Board name	*Description*
NRCOL (cont.)	LD3: V.OK: +12V from transformer secondary 2 OK
NRCON	• Board with microcontroller for kV regulation and generator control. • Communicates with console *(J6)* and with other generator boards *(J1)* via separate CAN buses. • Master board of generator: software of this board calculates and handles all main processes. • Measures capacitor bank voltage at charging procedure *(J2)*. • Supplies IGBT drive signals *(J2)* and gets feedback signals *(J4)* for kV regulation. • Different software versions for different kV and kW options. • Exposure counter and exposure logs are stored in this board. Test points: TP1: +5V in TP2: -15V in TP3: +15V in TP4: GND TP5: IGBT T3, "+" side driver signal, 50kHz PWM during exposure, TTL, active H TP6: IGBT T4, "-" side driver signal, 50kHz PWM during exposure, TTL, active H TP7: IGBT T3, "-" side driver signal, 50kHz PWM during exposure, TTL, active H TP8: IGBT T4, "+" side driver signal, 50kHz PWM during exposure, TTL, active H TP9: power OK: supply voltages (-5V, +10V, ±15V, isolated can +5V) are present, TTL, normally H TP10: SG out 1: Half bridge 1 controller signal, 50kHz PWM during exposure, TTL, active L TP11: SG out 2: Half bridge 2 controller signal, 50kHz PWM during exposure, TTL, active L TP12: kV comparator (not used) output, TTL TP13: SYNC: PWM modulator clock frequency, 100kHz pulses (always), TTL, active L TP14: SG RAMP: PWM oscillator, 100kHz, saw-tooth, always TP15: UDC: capacitor bank voltage, 0..4.6V=0..600V (400VAC mains) or 0..4.6V=0..400V (240VAC mains) TP16: SG comp: kV error amplifier output (PWM modulator input) TP17: KV REF: kV reference, 0..4.6V = 0..150kV TP18: DT1: dead time 1, 50kHz pulses under exposure TP19: kV difference between anode and cathode side: 0..12.78V = 0..150kV TP20: KV FB: kV feedback: 0..4.6V = 0..150kV TP21: MA: mA feedback, filtered. If D24(10mA), D25(100mA)=off: 1V=205mA, if D25(100mA)=on: 1V=21.9mA, if D24(10mA)=on: 1V=2.03mA TP22: mA feedback, unfiltered, scaling like TP21 TP23: DT2: dead time 2, 50kHz pulses under exposure Test LEDs: D1: (green) +5V supply voltage OK D2: (green) –15V supply voltage OK D3: (green) +15V supply voltage OK D4: (yellow) CAN1 TX: internal CAN bus transmit D5: (yellow) CAN1 RX: internal CAN bus receive

Board name	*Description*
NRCON (cont.)	D8: (yellow) LED0: error code flashing D9: (yellow) LED1: error code flashing D10: (yellow) LED2: error code flashing D11: (yellow) LED3: error code flashing D12: (red) FLASH PROG: processor is set to software download mode (by S2) D14: (yellow) CAN EXT TX: external CAN bus transmit D15: (yellow) CAN EXT RX: external CAN bus receive D16: (yellow) DEBUG RX: programming (serial) port receive D17: (yellow) DEBUG TX: programming (serial) port transmit D19: (yellow) EXP: console exposure request button is pressed D20: (yellow) PREP: console preparation request button is pressed D22: (green) +10V voltage OK D23: (green) –5V voltage OK D24: (yellow) MA LIMIT 10MA: mA feedback amplifier is set to x100 gain D25: (yellow) MA LIMIT 100MA: mA feedback amplifier is set to x10 gain D26: (yellow) VCC CAN: isolated +5V for external CAN bus OK Potentiometers: P1: DEAD TIME 1: IGBT dead time factory calibration (3µs) P2: SG FREQ: inverter frequency factory calibration (to output resonance frequency, around 100kHz) DIP switches: S1: CAN1: 1: (termination) always off, 2: (slew rate) always off S2: FLASH PROG: 1:off=normal use, on=software upgrade, 2: not used S3: CAN2: 1: (termination) off=fluoro remote controller connected, on=fluoro remote controller not connected, 2: slew rate, always off
NRMCU	• Daughter board for NRRAD • Contains microcontroller and software for NRRAD board • Don’t remove it from NRRAD: in case of fault replace them together. Test LEDs: LD1: (yellow) SIO RX: software upgrade serial port receive LD2: (green) +5V OK: +5V supply voltage OK LD3: (yellow) SIO TX: software upgrade serial port transmit LD4: (yellow) CAN TX: CAN bus transmit LD5: (yellow) CAN RX: CAN bus receive LD6: (red) ERROR1: error happened, error code flashing LD7: (red) ERROR2: error code flashing Test button: S1: SHOW ERROR: last error code is flashed on LD6, LD7
NRRAD	• Slave board with microcontroller. • Communicates with NRCON via CAN bus *(J11)*. • Standby and interface power supply. • Generator on/off circuit *(J19)* (for description see console) • Filament circuit *(J16)* • Low speed starter with output current measurement *(J2)* • Interlock inputs for 1 tube (door switch, tube temperature, tomo select, interlock) *(J6)* • Bucky control signals for 2 buckys (bucky start output, bucky ready

Board name	*Description*
NRRAD (cont.)	input) *(J4)* • Control of charger relay and main contactor in power input unit *(J17)* • Watchdog that can turn generator off in case of error • Error log, tube housing and insert settings, device settings, generator configuration and all calibration data are stored in this board *(U21)* Test points: TP1: SHIFT FIRE: rotor starter shift capacitor triac trigger signal, normally continuously on, off at DC brake, 5V, active L TP2: MAIN FIRE: rotor starter triac trigger signal, 50 Hz PWM when rotor is active, 5V, active L TP3: LINE POS: mains line 50Hz square signal, TTL TP4: BUCKY RDY: Bucky ready, TTL, active H TP5: -PREP: preparation active, 5V, active L TP6: +18V STBY: standby supply voltage "-" TP7: +18V STBY: standby supply voltage "+" TP8: FIL.FEEDB.: filament current RMS feedback, 0..4V=0..8A TP9: GND TP10: I MAIN: tube stator main winding current, 2V DC + 0..2V=0..20A 50Hz AC signal (when rotor is active) TP11: I SHIFT: tube stator shift winding current, 2V DC + 0..2V=0..20A 50Hz AC signal (when rotor is active) TP12: GND TP13: I Fil.: filament current RMS feedback to processor A/D, filtered, 0..4V=0..8A TP14: FIL.REF.: filament current reference, 0..4V=0..8A TP15: FIL.CT.: filament current feedback from current transformer, 20kHz AC signal, 0..4V=0..20A TP16: W.DOG IN: watchdog refresh signal, 100 Hz, pulses, TTL, active H TP17: SG SYNC: filament PWM regulator oscillator frequency, 40kHz, TTL, always TP18: SG OUT Q9: driver signal for filament inverter FET Q9, 20kHz PWM if filament is active, 15V, active H TP19: SG OUT Q8: driver signal for filament inverter FET Q8, 20kHz PWM if filament is active, 15V, active H TP20: CANL: internal CAN bus TP21: CANH: internal CAN bus TP22: Q8 G: gate of filament inverter FET Q8 TP23: Q8 S: source of filament inverter FET Q8 TP24: GND TP25: Q9 G: gate of filament inverter FET Q9 TP26: W.DOG OUTPUT: watchdog output, active in case of error, 5V, active H TP27: +24V supply voltage TP28: Q9 S: source of filament inverter FET Q9 TP29: +15V supply voltage TP30: -15V supply voltage TP31: +5V supply voltage TP32: +24V(CON): supply voltage "-" TP33: +24V(CON): supply voltage "+" for console, standby: 16.6V, generator on: 22.6V

Board name	*Description*
NRRAD (cont.)	Test LEDs: LD1: (green) +18V(IF) supply voltage OK LD2: (yellow) SHIFT FIRE: normally on, off at rotor DC brake LD3: (yellow) MAIN FIRE: rotor starter operating LD4: (green) LINE OK: mains voltage for rotor starter OK LD5: (yellow) BUCKY2 SEL: off: bucky 1 is selected, on: bucky 2 is selected LD6: (yellow) BUCKY STRT: bucky start signal is on LD7: (yellow) BUCKY RDY: bucky ready signal is present LD8: (yellow) DOOR LIGHT: door lamp is on (preparation) LD9: (yellow) INTERLOCK: preparation is not inhibited LD10: (yellow) TOMO: tomography is selected on table LD11: (yellow) TUBE TEMP: tube not overheated LD12: (yellow) DOOR SW: door closed LD13: (yellow) TUBE2: 2nd tube is selected on high voltage tank LD14: (yellow) TUBE CHG: tube selector motor is operating (about 200 ms at tube change) LD15: (green) filament inverter FET Q8 isolated supply voltage OK LD16: (green) HVDC- OK: filament inverter "-" side voltage OK LD17: (green) HVDC+ OK: filament inverter "+" side voltage OK LD18: (green) filament inverter FET Q9 isolated supply voltage OK LD19: (green) +24V supply voltage OK LD20: (green) +15V supply voltage OK LD21: (green) +18V IF supply voltage OK LD22: (yellow) LARGE FOCAL SPOT selected LD23: (yellow) CHARGER: charger relay RY2 in power input unit on LD24: (yellow) MAIN: main contactor RY1 in power input unit on LD25: (yellow) GEN.ON: generator on LD26: (green) +5V supply voltage OK LD27: (green) +24V(CON) console supply voltage OK LD28: (red) WATCHDOG ERROR: software on NRMCU is not running Potentiometer: P1: filament current factory calibration Jumpers: JP1: 24V INTERFACE: bucky interface voltage level: on=24V, off=230V JP2: 24V INTERFACE: like JP1 JP3: 24V INTERFACE: like JP1 JP4: IF POLARITY: interface voltage polarity for signals TOMO SEL, INTERLOCK. Factory default: 1-3 JP5: IF POLARITY: like JP4 JP6: DISABLE WD SHUTDOWN: watchdog can not turn generator off if this jumper is on (normally off, troubleshooting or software download: on)
NRTUS	• Tube selector board (optional: 2-tube versions only). • Multiplexer for interlock, bucky and rotor signals that connect signals of selected tube to board NRRAD • Driving tube selector magnets inside the high voltage tank • Communicates with NRRAD by dedicated signals *(J1)*: *TUBECHG:* tube change impulse from NRRAD: proper tube selector magnet is working while this pulse is active *TUBE2:* selected tube feedback for NRRAD: active if tube 2 is selected (no change while *CHG* impulse is active)

Board name	*Description*
NRTUS (cont.)	Test LEDs: LD1: TUBE1 is selected LD2: TUBE2 is selected

2.4.2 High speed starter and fluoro unit (option)

Board / component name	*Description*
CSTIF	• Interface board for tomographic table. • Supplies and gets start and ready signals from 24VDC tomographic table and 230VAC bucky. • Connected to 230VAC bucky output of NRRAD.
NRFIL	• Filament board for small focal spot • Gets supply voltage and dedicated control signals from NRFIL *(J3)*: *FIL ENABLE:* if active, filament PWM controller circuit is on *-FILDA LD:* loads the transferred value to D/A converter's output *-FILDA CLR:* sets output of filament reference D/A converter to zero *FILDA CLK:* clock signal for reference transfer *FILDA SDI:* data signal for reference transfer • Supplies filament current feedback signal to NRFIL *(J3, FIL CUR)* • Contains controller daughter board NRFIL CTR Test points on NRFIL: TP1: gate of FET Q1 TP2: source of FET Q1 TP3: source of FET Q2 TP4: gate of FET Q2 Test points on NRFIL_CTR: TP1: Filament current RMS feedback, filtered, 0..4V=0..8A TP2: Filament current reference, 0..4V=0..8A TP3: SG Sync: PWM regulator oscillator frequency, 40kHz, TTL, always TP4: SG out Q2: driver signal for FET Q2, 20kHz PWM if filament is active, 15V, active H TP5: Filament current RMS feedback, 0..4V=0..8A TP6: Filament CT: filament current feedback from current transformer, 20kHz AC signal, 0..4V=0..20A TP7: SG out Q1: driver signal for FET Q1, 20kHz PWM if filament is active, 15V, active H Test LEDs (on NRFIL): LD1: (green) DC- OK: "-" side voltage for inverter OK LD2: (green) DC+ OK: "+" side voltage for inverter OK LD3: (green) isolated supply voltage for FET Q1 OK LD4: (green) isolated supply voltage for FET Q2 OK Potentiometer (on NRFIL_CTR): P1: filament current factory calibration
NRFIF	• Fluoroscopy interface board with microcontroller • Communicates with NRCON and NRRAD via CAN bus • Optocoupled input and output signals for external devices • Inputs and outputs can be configured from software • ABS input

Board / component name	*Description*
NRFIF (cont.)	• Supplies hardware X-ray enable signal to NRCON *(J14)* • Controls small filament with board NRFIL Test points: TP1: ABS signal to processor A/D converter, 0..4V TP2: GND TP3: ABS+: signal point of ABS input connector J8 TP4: ABS-: shield of ABS input connector J8 TP5: ABS IN: ABS signal, video: 5Vpp, DC: 0..10V Test LEDs: LD1: (yellow) IN11 software configurable input LD2: (yellow) IN12 software configurable input LD3: (yellow) IN13 software configurable input LD4: (yellow) OUT3 software configurable output LD5: (yellow) OUT4 software configurable output LD6: (green) 24VIF OK: +24V interface supply voltage OK LD7: (yellow) FL.KV.EN: fluoro kV enable input LD8: (yellow) PWM ABS input LD9: (yellow) OUT2 software configurable output LD10: (yellow) OUT1 software configurable output LD11: (yellow) IN10 software configurable input LD12: (yellow) IN9 software configurable input LD13: (yellow) IN8 software configurable input LD14: (yellow) IN7 software configurable input LD15: (yellow) IN6 software configurable input LD16: (yellow) IN5 software configurable input LD17: (yellow) DEV.EXP: radiographic exposure request input LD18: (yellow) DEV.PREP: radiographic preparation request input LD19: (yellow) FOOT SW: fluoro preparation request input LD20: (yellow) IN4 software configurable input LD21: (yellow) IN3 software configurable input LD22: (yellow) IN2 software configurable input LD23: (yellow) IN1 software configurable input LD24: (yellow) FLUORO: fluoro preparation output LD25: (yellow) PREP: radiographic preparation output LD26: (green) +24V supply voltage OK LD27: (yellow) OUT5 software configurable output LD28: (green) +15V supply voltage OK LD29: (yellow) OUT6 software configurable output LD30: (green) –15V supply voltage OK LD31: (yellow) OUT7 software configurable output LD32: (yellow) WHITE (DIRECT): white level of ABS video signal LD33: (green) +5V supply voltage OK LD34: (yellow) OUT8 software configurable output LD35: (yellow) AVG (HELD): average level of ABS signal. Signal follows input signal when X-ray is on, otherwise it is held in its last value. LD36: (red) WATCHDOG ERROR: software on NRMCU is not running LD37: (yellow) OUT9 software configurable output LD38: (yellow) OUT10 software configurable output LD39: (yellow) OUT11 software configurable output LD40: (yellow) OUT12 software configurable output LD41: (yellow) IN14 software configurable input

Board / component name	*Description*
NRFIF (cont.)	LD42: (yellow) IN15 software configurable input LD43: (yellow) IN16 software configurable input LD44: (yellow) IN17 software configurable input LD45: (yellow) IN18 software configurable input LD46: (yellow) IN19 software configurable input Potentiometers: P1: WHITE: weight of white level for ABS operation P2: AVG: ABS level, gain, weight of average for ABS operation Jumpers: JP1: GND of generator is connected to interface circuit of connector J2 JP2: +24V generator interface voltage is connected to interface circuit of connector J2 JP3: polarity configuration for fluoro kV enable input JP4: polarity configuration for PWM ABS input JP5: C+: polarity for connector J2: "common +" JP6: C-: polarity for connector J2: "common -" JP7: GND of generator is connected to interface circuit of connector J3 JP8: +24V generator interface voltage is connected to interface circuit of connector J3 JP9: C+: polarity for connector J3: "common +" JP10: C-: polarity for connector J3: "common -" JP11: polarity configuration for output 2 JP12: polarity configuration for output 1 JP13: polarity configuration for input 10 JP14: polarity configuration for input 9 JP15: polarity configuration for input 8 JP16: polarity configuration for input 7 JP17: polarity configuration for input 6 JP18: polarity configuration for input 5 JP19: polarity configuration for rad. exposure request input JP20: polarity configuration for rad. preparation request input JP21: polarity configuration for fluoro preparation request input JP22: polarity configuration for input 4 JP23: polarity configuration for input 3 JP24: polarity configuration for input 2 JP25: polarity configuration for input 1 JP26: GND of generator is connected to interface circuit of connector J4 JP27: +24V generator interface voltage is connected to interface circuit of connector J4 JP28: polarity configuration for input 11 JP29: polarity configuration for input 12 JP30: polarity configuration for input 13 JP31: C+: polarity for connector J4: "common +" JP32: C-: polarity for connector J4: "common -" JP33: polarity configuration for output 3 JP34: polarity configuration for output 4 JP35: +24V generator interface voltage is connected to interface circuit of connector J5 JP36: C-: polarity for connector J5: "common -"

Board / component name	*Description*
NRFIF (cont.)	JP37: GND of generator is connected to interface circuit of connector J5 JP38: C+: polarity for connector J5: "common +" JP39: +24V generator interface voltage is connected to interface circuit of connector J6 JP40: C-: polarity for connector J6: "common -" JP41: GND of generator is connected to interface circuit of connector J6 JP42: C+: polarity for connector J6: "common +" JP43: polarity configuration for fluoro req. output JP44: polarity configuration for prep req. output JP45: polarity configuration for output 5 JP46: polarity configuration for output 6 JP47: DC,V/PWM: ABS signal source, 1-2 (DC,V): ABS from DC voltage or video signal, 2-3 (PWM): ABS from PWM input JP48: VIDEO: on=white level has effect on ABS (ABS from video signal), off=only average level has effect (ABS from DC voltage) JP49: DC: ABS preamplifier gain: on=x1 (ABS from DC voltage), off=x5 (ABS from video signal) JP50: DC: off=AC coupling of ABS signal for setting video sync level around GND (ABS from video signal), on=DC coupling (ABS from DC voltage) JP51: polarity configuration for output 7 JP52: 75R: 75Ω termination for ABS input (video) JP53: polarity configuration for output 8 JP54: GND: connects ABS- input and generator GND together JP55: DC: AC or DC coupling of ABS signal (on=ABS from DC voltage, off=ABS from video signal) JP56: DC: ABS preamplifier gain: on=x1 (ABS from DC voltage), off=x5 (ABS from video signal) JP57: polarity configuration for output 9 JP58: DC: AC or DC coupling of ABS signal (on=ABS from DC voltage, off=ABS from video signal) JP59: polarity configuration for output 10 JP60: polarity configuration for output 11 JP61: polarity configuration for output 12 JP62: polarity configuration for input 14 JP63: polarity configuration for input 15 JP64: polarity configuration for input 16 JP65: polarity configuration for input 17 JP66: polarity configuration for input 18 JP67: polarity configuration for input 19 JP68: FL.KV.EN=FOOT SW: if on, fluoro preparation request signal activates fluoro kV enable signal too
NRHSF	• Output EMI filter for high speed starter
NRLHS	• Dual speed starter (60 Hz and 180 Hz) board with microcontroller • Communicates with NRRAD via CAN • Generates output voltage from voltage of capacitor bank • Works with two phase shift capacitors: for 180 Hz rotation connects

Board / component name	*Description*
NRLHS (cont.)	them serially, for 60 Hz rotation paralelly • Reads rotation parameters from NRRAD • Logs errors on NRRAD • Output current measurement for protection and heat calculation • Capacitor bank voltage measurement for regulated output voltage • Overcurrent protection • IGBT overtemperature protection • Measurement of rotor speed on some type of tubes, run voltage is applied only if speed is low • Watchdog that inhibits inverter operation in case of microcontroller failure Test points: TP1: SPEED FREQ FB: anode speed frequency square wave during speed measurement, TTL TP2: DIRECTION: output voltage polarity, TTL, L=positive, H=negative, 60Hz or 180Hz during rotation TP3: PWM: active if output voltage is on, 360Hz period, active L, TTL TP4: I SHIFT: tube stator shift winding current, 2V DC + 0..2V=0..40A 60/180Hz AC signal, when rotor is active TP5: I MAIN: tube stator main winding current, 2V DC + 0..2V=0..40A 60/180Hz AC signal, when rotor is active TP6: GND TP7: U DC: capacitor bank voltage, 0..4V=0..600V TP8: SPEED: frequency feedback from tube stator, square wave, TTL TP9: Q1 E: inverter IGBT Q1 emitter TP10: Q1 G: inverter IGBT Q1 gate TP11: Q3 E: inverter IGBT Q3 emitter TP12: Q3 G: inverter IGBT Q3 gate TP13: G2 E: inverter IGBT Q2 emitter TP14: Q2 G: inverter IGBT Q2 gate TP15: Q4 E: inverter IGBT Q4 emitter TP16: Q4 G: inverter IGBT Q4 gate TP17: IGBT TEMP.: from IGBT temperature sensor, about 12V at 25°C Test LEDs: LD1: (green) +24V supply voltage OK LD2: (green) +15V supply voltage OK LD3: (green) +5V supply voltage OK LD4: (green) –15V supply voltage OK LD5: (red) WATCHDOG: software on NRMCU is not running LD6: (red) OVERCUR: overcurrent happened on IGBTs, operation inhibited LD7: (red) IGBT HOT: temperature of IGBTs is higher than 85°C LD8: (yellow) Q1: IGBT Q1 on LD9: (yellow) Q3: IGBT Q3 on LD10: (yellow) Q2: IGBT Q2 on LD11: (yellow) Q4: IGBT Q4 on LD12: (green) UQ1: isolated supply voltage for IGBT Q1 OK LD13: (green) UQ3: isolated supply voltage for IGBT Q3 OK LD14: (green) UQ2: isolated supply voltage for IGBT Q2 OK

Board / component name	*Description*
NRLHS (cont.)	LD15: (green) UQ4: isolated supply voltage for IGBT Q4 OK LD16: (green) HVDC PRESENT: +600V from capacitor bank OK Potentiometer: P1: SPEED SIGNAL SENSITIVITY: anode speed feedback signal minimal amplitude (factory setting: 50mV)
NRMCU	• Daughter board for NRLHS and NRFIF • Contains microcontroller and software for NRLHS or NRFIF board • Don't remove it from NRLHS or NRFIF: in case of fault replace them together. Test LEDs: see at controller unit
TXCAA	• EMI filter inductor • Also important for overcurrent protection
TXFAA	• Fuse board between capacitor bank and high speed starter board

2.4.3 Inverter unit

Board name	*Description*
HFIDD	• IGBT driver, daughter board of HFIGB. • Don't repair it, replace it if it is faulty. (Or replace whole HFIGB.)
HFIGB	• IGBT driver board for main inverter. • Receives IGBT control signals from HFIIB *(J5)*. • Supplies drive signals for IGBTs *(J1-J4)*. • Sends IGBT overcurrent error signal to HFIIB *(J6).* • Sends "auxiliary supply voltage OK" signals for each IGBT to HFIIB. *(J7)* Test points: TP1: GND TP2: +15V supply voltage TP3: oscillator output for IGBT supply transformers, 15V, 400kHz square wave TP4: like TP3, but opposite polarity TP5: driver output for IGBT supply transformers, 15V, 400kHz square ware TP6: like TP5, but opposite polarity Test LED: L1: (red) +15V supply voltage OK Potentiometer: P1: OSC. FREQUENCY SETTING: IGBT supply oscillator frequency factory setting, 400kHz
HFIIB	• Inverter interface board between the controller and inverter part. • Receives the following signals from NRCON *(S12):* IGBT control signals for 4 IGBTs of main inverter *-CLEAR ERROR:* clears error signals *INV.ERROR* and *INV.FAT.ERROR* coming from HFIIB to NRCON. (You can also clear these error signals by pushing button *B1* on HFIIB.) *-PREP./EXP.:* active under preparation, but not active under

Board name	*Description*
HFIIB (cont.)	exposure. Capacitor bank voltage is checked only if the signal is active. *POWER SELECT:* HV tank primary selector signal: goes to TXPSC *(S4).* *POWER PREP*: goes to TXPSC *(S8).* • Sends following signals to NRCON *(S12)*: -*INV.FAT.ERROR:* fatal inverter error. This signal remains active until it is cleared on the following conditions: - capacitor bank overvoltage (signed by LEDs **D12** and **D46**): can be active if input mains voltage is higher than 440VAC - capacitor bank asymmetry (signed by LED **D46**, **D12** is dark): active if voltage difference between serial connected capacitors is more than 70V - aux. power error: one (or more) IGBT driver supply voltages is missing on board HFIGB. This error is signed by LED **D45**. You can check auxiliary power ready signals from HFIGB on LEDs **D5-D8**: they are lit if power is OK. - IGBT overheating (signed by LED **D44**) from temperature sensor switch connected to *S3*. Normally temp. sensor switch is closed, above 50°C it is open. - HV tank overheating (signed by LED **D39**) from temperature sensor switch connected to *S2*. Normally temp. sensor switch is closed, above 50°C it is open. -*INV.ERROR*: inverter error. This signal gets and remains active until it is cleared at following conditions: - capacitor bank error (signed by LED **D13**): voltage of capacitor bank is lower than about 400VDC. This voltage is detected only at preparation (but not under exposure). - inverter overcurrent (signed by LED **D9**): output current of main inverter (measured by TXAVB) is too high - IGBT overcurrent (signed by LED **D19**): main inverter current is too high (error signal from HFIGB). Maybe one of IGBTs is damaged (went to short circuit). Check IGBTs with multimeter when generator is off and capacitor bank is discharged: • disconnect driver wires of IGBTs T3, T4 from HFIGB board. Measure resistance between IGBT drive pins (gate and emitter). If you measure less than ∞ Ω, replace IGBT module. • measure free wheeling diodes of IGBTs (between IGBT module output pin (that is connected to high voltage tank or thyristor modules TM1, TM2) and capacitor bank + and -). If you measure short circuit, replace IGBT. - optional (signed by LED **D15**): spare error signal from *S10* to further development. -*UDC:* analog signal that is proportional to capacitor bank voltage Test points: TP1: GND TP2: +15V supply voltage TP3: +5V supply voltage TP4: IGBT T3+ driver signal, TTL, active L TP5: IGBT T3- driver signal, TTL, active L TP6: IGBT T4+ driver signal, TTL, active L

Board name	*Description*
HFIIB (cont.)	TP7: IGBT T4- driver signal, TTL, active L TP8: IGBT T3+ driver signal, delayed, 15V, active L TP9: IGBT T3- driver signal, delayed, 15V, active L TP10: IGBT T4+ driver signal, delayed, 15V, active L TP11: IGBT T4- driver signal, delayed, 15V, active L TP12: capacitor bank voltage low error, 15V, active H TP13: capacitor bank asymmetry and/or overvoltage, 15V, active L TP14: GND of capacitor bank voltage measuring circuit TP15: +15V supply voltage for capacitor bank voltage measuring circuit (from NRCON) TP16: measured voltage of capacitor bank, 400VAC mains: 0..10V=0..600V, 240VAC mains: 0..10V=0..400V TP17: inverter overcurrent error, 15V, active H TP18: IGBT overcurrent error, 15V, active L TP19: IGBT temperature high error, 15V, active H TP20: high voltage tank temperature high error, 15V, active H TP21: power switch enable signal, active at preparation, 15V, active L TP22: power switch control signal, active above 100kV, 15V, active H TP23: capacitor voltage low protection enable signal, active at preparation, inactive during exposure, 15V, active L TP24: error clear signal, from NRCON, active at generator startup and for 1ms at the beginning of preparation, 15V, active L TP25: same as TP24 TP26: *INV.ERROR* collected error signal to NRCON, 15V, active L TP27: *INV.FAT.ERROR* collected error signal to NRCON, 15V, active L Test LEDs D5: (green) AUX. POW. CHECK I.: isolated supply voltage for IGBT T4- OK D6: (green) AUX. POW. CHECK II.: isolated supply voltage for IGBT T4+ OK D7: (green) AUX. POW. CHECK III.: isolated supply voltage for IGBT T3- OK D8: (green) AUX. POW. CHECK IV.: isolated supply voltage for IGBT T3+ OK D9: (red) INV. OVERCURRENT: inverter overcurrent error D10: (green) UPPER CAP. BANK OK: + side of capacitor bank (400VAC input voltage) or capacitor bank voltage (240VAC input voltage) OK D11: (green) LOWER CAP. BANK OK: - side of capacitor bank voltage OK (400VAC input voltage only) D12: (red) CAP. BANK OVERVOLTAGE: capacitor bank overvoltage D13: (red) CAP. BANK ERROR: voltage on any side of capacitor bank is too low D15: (red) OPT: spare error signal, not used D19: (red) IGBT OVERCURRENT error D39: (red) TANK O.HEAT: temperature of high voltage tank too high D44: (red) IGBT OVERHEAT: temperature of IGBT heatsink too high D45: (red) AUX. POW. ERR.: supply voltage of an IGBT is missing D46: (red) CAP. BANK FAT. ERROR: capacitor bank overvoltage and/or asymmetry D50: (green) +15V supply voltage OK

Board name	*Description*
HFIIB (cont.)	D52: (green) +5V supply voltage OK Potentiometers: P1: safety dead time for IGBT T3+ P2: safety dead time for IGBT T3- P3: safety dead time for IGBT T4+ P4: safety dead time for IGBT T4- Jumpers: JP1: voltage level for capacitor bank minimum voltage protection: 1-3=240VAC, 2-3=400VAC mains voltage JP2: voltage level for capacitor bank overvoltage protection: open=400VAC, closed=240VAC mains voltage JP3: voltage level for capacitor bank minimum voltage protection: open=400VAC, closed=240VAC mains voltage JP4: connection of GND and PE, normally closed JP7: voltage level for capacitor bank voltage measurement: open=400VAC, closed=240VAC mains voltage JP8: like JP7 JP9: IGBT supply voltage check: open=disabled, closed=enabled, normally closed Push button: B1: stored errors can be cleared by pushing this button
HFRCB	• Snubber board for main inverter IGBTs
TXAVB	• Current transformer board for measuring inverter output current Jumpers: JN1..JN4: Current sensitivity. Factory configuration: JN1: open, JN2..4: closed
TXPSC	• HV tank primary selector board (optional: on higher kW versions only) • Drives thyristors that switch output to selected primary winding of HV tank. • Receives selector *(S5)* and preparation *(S6)* signals through HFIIB board from NRCON board. • Drives thyristor gates only under preparation. Test points: TP1: GND TP2: +15V supply voltage TP3: oscillator frequency, 800kHz, 15V Test LEDs: D19: (red) +15V supply voltage OK D20: (red) thyristor TM1/4-5 on D21: (red) thyristor TM1/6-7 on D22: (red) thyristor TM2/4-5 on D23: (red) thyristor TM2/6-7 on Potentiometer: P1: oscillator frequency, 800kHz
TXRDV	• Capacitor bank discharge board • Makes voltage of capacitor bank symmetrical
TXSRC	• Snubber board for TXPSC (optional) Different versions for thyristor modules TM1, TM2

2.4.4 Filter box

Board / component name	*Description*
HF3FF	Line input EMI filter
ILFCP	EMI filter capacitor board in HF3FF
TX3FF	Line input EMI filter
TXCOM	Snubber board for rectifiers
TXACD	EMI filter choke in TX3FF
TXDCF	EMI filter capacitor board on main inverter DC voltage
TXDMP	EMI filter choke for main inverter DC voltage
TXHCA	EMI filter capacitor board in TX3FF
TXHCB	EMI filter capacitor board in TX3FF

2.4.5 Console

Board name	*Description*
NRSRC	• Board with microcontroller for handling display and keyboard. • Communicates with generator via CAN bus *(CON3)*. Dedicated prep, exp signals to generator for safety *(CON1)*. • Isolated RS-232 for installation with PC *(CON2)*. • Supplies also backlight *(CON5)* and contrast voltages for LCD. • Contains part of generator on/off circuit (the other part is on NRRAD board). Signals between NRSRC and NRRAD on/off circuit *(CON1)*: *EXTERNAL POWER/+24V(CON):* supply voltage for console: ≈+16V on standby (generator off), ≈+22V if generator is on *OFF LED/-CONSOLE ON:* NRRAD connects it to GND if generator is off (in this case console is off too) *ON LED/ON SW:* console connects it to GND if ON key is pushed. This activates RY3 on NRRAD, which connects this point to GND and remains active. Generator is turned on, ON LED is lit. *OFF SW/ON RELAY+:* supply voltage for NRRAD RY3 relay coil from console. If OFF key is pushed or console cable is disconnected, this voltage disappears and RY3 releases. Generator turns off. • Anatomical programs and console settings are stored in this board. Test points: TP1: +24V supply voltage from generator: standby: 16.6V, generator on: 22.6V TP2: +5V pw.: +5V supply voltage TP3: +5V supply voltage TP4: +24V supply voltage, like TP1 TP5: +12V supply voltage TP6: -22V supply voltage TP7: BCK.REF: +5V reference voltage TP8: +5V supply voltage

Board name	*Description*
NRSRC (cont.)	TP9: GND TP10: +3.3V supply voltage TP11: +5V supply voltage TP12: GND TP13: GND TP14: CONTR: LCD contrast voltage, -10..-22V TP19: +12V supply voltage TP24: EXT-PRG: software download mode is selected for processor, TTL, active L TP25: GND TP26: SIN: serial data for LED display latch, active at display value change, TTL, active L TP27: SRCK: clock for LED display latch serial programming, about 260kHz, active at display value change, TTL, active L TP28: CLR: clears LED display latch, TTL, active L TP29: RCK: stores downloaded data to LED display latch, pulse at display value change, TTL, active L TP30: GATE: LED display is on if this signal is active, PWM, duty cycle depends on brightness setting, TTL, active L Test LEDs: LED1: (green) +5V supply voltage OK LED2: (green) isolated +5V for PC RS-232 communication OK LED3: (yellow) UART TX: transmit to PC RS-232 LED4: (yellow) UART RX: receive from PC RS-232 LED5: (yellow) CAN TX: transmit to generator CAN bus LED6: (yellow) CAN RX: receive from generator CAN bus LED10: (red) PRG: software download mode for processor LED35: (green) isolated +5V for generator CAN communication OK

2.4.6 Fluoro remote controller

Board name	*Description*
NRSFC	• Board with microcontroller for handling display and keyboard. • Communicates with generator via CAN bus *(CON3).* • Isolated RS-232 for installation with PC *(CON2)*. • Optocoupled output signals for image intensifier and camera *(CON6).* • Settings, fonts and texts of fluoro remote controller are stored on this board Test LEDs: LED1: (green) +5V supply voltage OK LED3: (yellow) UART TX: transmit to PC RS-232 LED4: (yellow) UART RX: receive from PC RS-232 LED5: (yellow) CAN TX: transmit to generator CAN bus LED6: (yellow) CAN RX: receive from generator CAN bus LED10: (red) software download mode for processor LED35: (green) isolated +5V for generator CAN communication OK Jumper: JP2: generator CAN bus termination 120Ω, open=off, closed=on, normally closed

3. TROUBLESHOOTING

This chapter helps you to find faulty board or component in TOP-X 100NR generator.

3.1 Errors without error message

3.1.1 Generator can not be turned on

Symptom	*Reason*	*Action*
1. *Off* LED does not light on console, and keys *ON/OFF* do not work	Standby voltage is missing.	Check mains power. Check LED *LD27* (+24V CON) on board NRRAD. • if it is on: check cables from NRRAD to console • if it is off: check 230VAC standby voltage on NRRAD J1/1,2. If it presents, replace NRRAD. If it is missing, replace fuse F6 in power input unit
2. *Off* LED is OK, but there is no change to *On* LED after pushing *ON* button on console	Fault in on/off circuit.	Check signals of on/off circuit between board NRRAD and console according to description in chapter 2.4.7 (NRSRC board).
3. Both *On* and *Off* LEDs are lit after pushing *ON* key, but console is not working	+24V is missing or console fault.	Check LED *LD19* (+24V) on board NRRAD. • if it is on: replace NRSRC board in console • if it is off: check fuse *F6* on NRRAD, fuse *F8* in power input unit and power supply *PS2*

3.1.2 Generator turns off without pushing OFF button

Symptom	*Reason*	*Action*
1. Generator turns off after pushing *ON* within less than 1 s	Watchdog shutdown on NRRAD board. Microcontroller U3 on NRMCU of NRRAD is likely to have gone wrong.	Replace NRRAD
2. Generator turns off after pushing *ON* in about 5 s, without activating charger relay *RY2* in power input unit	CAN communication is not working between boards NRCON and NRRAD	Measure resistance between test points *TP20* (CANL) and *TP21* (CANH) of board NRRAD. • if the resistance is different from ≈ 60Ω, it can be because of cable or termination problem. Check power+CAN cable between NRRAD and NRCON and check

Symptom	*Reason*	*Action*
		that CAN bus is terminated on both ends by 120Ω. • if resistance is around 60Ω, replace both NRCON and NRRAD boards
3. Generator turns off under normal conditions	Contact fault in console cable	Check console cable
	Input mains voltage is too low	• Check input mains voltage. • Check voltage on coil of generator turn on relay (*RY3* on board NRRAD). It should be at least 8.5V when generator is on.
	2 boards can turn generator off: NRCON or NRRAD	Close jumper *JP6* (DISABLE WATCHDOG SHUTDOWN) on board NRRAD. If the generator still turns off, error is generated by NRCON, otherwise by NRRAD.
	turn off by NRCON: CAN communication error	Read code of last error from NRCON after a turn-off (see chapter 3.2.3).
	turn off by NRRAD: • mains input AC voltage is missing on *J9* of NRRAD for more than 65 ms • interface voltage (+18VIF) is missing	If these conditions are not fulfilled, replace NRRAD.

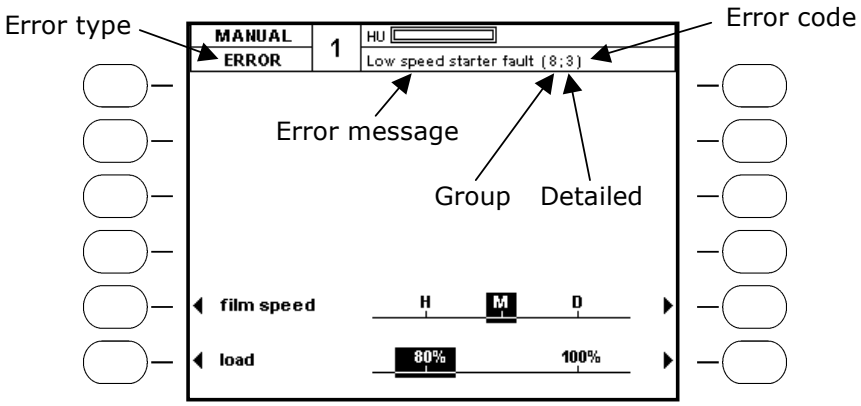
3.2 Errors with error message

When a processor detects failure during generator operation, error event is generated. In this case:

- Error message and error code are displayed on console display.
- Error code, date and time are logged (in case of most errors).
- Depending on the error type one of the following actions is done:
  - **WARNING**: in case of errors and failures that are not dangerous for patient or for the equipment, only a warning message is displayed, but no other action happens
  - **ERROR**: in case of errors and failures when it would be dangerous for the patient or equipment to make an exposure, preparation is inhibited
  - **SAFE MODE**: in case of serious failures when generator operation is not allowed, main relay *RY1* switches off (safe mode), and no operation is allowed until generator is turned off. (But you can read error message from the console.)
  - **GEN. OFF**: at very serious communication problems or when supply power is missing, generator turns off (as if you push *OFF* button on the console). For detecting reason of these failures see chapter 3.1.2.

3.2.1 Error message on console

In case of error you can find an error message on console:



Error type: Type of error event (warning, error, safe mode, gen. off).

Error message: Message according to error group code. These messages can be translated to the language of the user, see chapter 4.6.2 of documentation *R-3241 Generator setup.*

Error code: Code of error. This is independent from language. You can find meanings of errors in this documentation with this code. Please also use this code when you contact us.

Group: Code of error group. Some errors are categorized into groups and have the same error message (e.g. "Filament fault").

Detailed: Errors that are collected to groups can be distinguished by this number.

3.2.2 Reading error log

You can read error log with PC in the following way:

1. Connect PC to console and start service program according to chapter 4.1 of document *R-3241 Generator setup*.
2. Prepare console to data transfer according to chapter 4.2.1 of document *R-3241 Generator setup*.
3. Read error log according to chapter 4.2.5 of document *R-3241 Generator setup.*
4. You can also read data and reason of exposures terminated by "Beam fault" (see chapter 4.2.4 of document *R-3241 Generator setup*).
5. Error log can be saved to file so as to open it in the office or to send it by e-mail.

3.2.3 Reading last error code from NRCON

If the generator has turned off because of an internal error, you can the read error code of the last error of board NRCON (probably the error which caused generator turn off) the following way:

1. Turn generator on.
2. Push button **S1** on extension board NRMCU of board NRRAD.
3. You can find last error of NRCON on the console display.
4. You can also read error code from LEDs of NRCON.
   After pushing **S1** LEDs **LED1**-**LED3** on board NRCON start to flash. Count for each LED how many times has it flashed. Make the error code according to the following table:

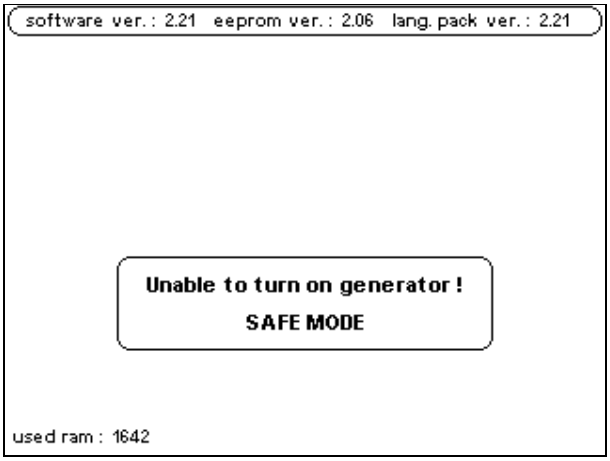
   1 flash of **LED1** = 100
   1 flash of **LED2** = 10
   1 flash of **LED3** = 1

   For example: **LED2** flashes 5 times, after **LED3** flashes 3 times: in this case error code is 53.
5. If flashed error code is above 31, it is a real error code you can decode with chapter 3.3. If it is below 10, it means a beam fault (code 25), with the following reason:

Flashed code	Reason	Detailed code (see chapter 3.3.25)
1	Power supply fault	16
2	kV asymmetry – anode side	1
3	kV asymmetry – cathode side	2
4	Inverter error	3
5	High voltage arc – anode side	32
6	High voltage arc – cathode side	64
7	kV overvoltage	128
9	Fatal inverter error	256

3.2.4 Console: "Unable to turn on generator"

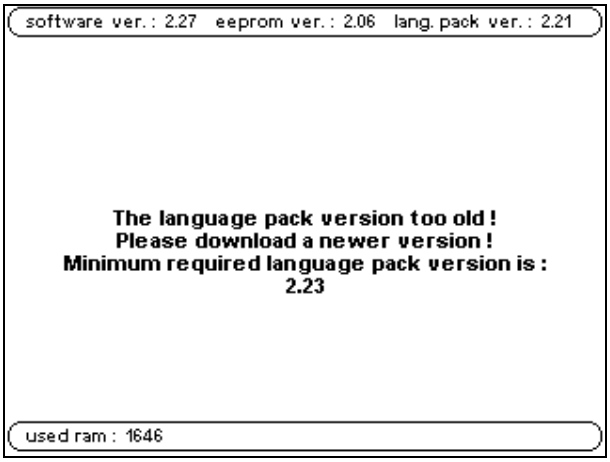
After power on this error message can appear on console:



The reason of this message is a CAN communication problem between console and NRCON. If NRCON does not work at all, you will get this message.

3.2.5 Console: "Language pack version too old"

After power on this error message can appear on console:



The reason of this message is that new software version of console software requires a new language file, because new messages have been added to console.

If you want a console with English language, simply download the new language file which is written to the CD of the generator ("console_english_... .lng", see chapter 4.2.1 of document *R-3241 Generator Setup*).

If you already translated console messages to your language, import new language file to your old, translated language file and translate new messages (see chapter 4.6.4 of document *R-3241 Generator Setup*).

3.3 List of error messages

3.3.1 Error group 1: Tube hot

Code	*Reason*	*Action*
1 ; 1	Short circuit is missing from J6/3-4 on board NRRAD. It can caused by connected overtemperature sensor on X-ray tube.	Apply a short circuit to pins 3-4 of connector J6 of board NRRAD. If error still exists, replace NRRAD.
1 ; 2	Preparation when tube is too hot.	See above.

3.3.2 Error group 2: Tube change fault

Code	*Reason*	*Action*
2 ; 1	Preparation when tube change is in progress.	After selecting another device on console don't push preparation button until tube change is finished.
2 ; 2	Unsuccessful tube change. Tube change is tried 3 times, but without success: feedback signal *Tube2* is not in good state.	Check motor operation during the tube change. If motor is not operating: • check LED LD14 *(Tube Chg)* on NRRAD. If it does not flash, replace NRRAD. • apply a short circuit to pins 3-4 of U17 on NRRAD for a moment. If tube selector motor operates, replace NRRAD. • leave short circuit on NRRAD/U17/3-4. Check way of motor signal: NRTUS/J1/2-GND, NRTUS/J7/4-5, TXTTC/S1/1-2, motor/gray, blue. Replace board or cable where signal disappears. If motor is operating, move motor by hand and check way of position feedback signal: motor/brown-black, TXTTC/S1/3-GND, NRTUS/J7/3-GND, NRTUS/J1/4-GND, NRRAD/J8/3-4. Replace board or cable where signal disappears.
2 ; 3	The selected tube is not configured. Device configuration contains a tube that is disabled at tube configuration.	Correct tube settings and/or device configuration. (See chapters 4.2 and 4.5.2 of document *R-3241 Generator setup*)
2 ; 4	Preparation at tube selector check and DC brake at startup. If 2 tubes are configured, after power on generator select both	Don't push preparation on console during this startup procedure.

Code	Reason	Action
	tubes to check tube selector. If DC brake is configured, selected tube is braked to standstill.	

3.3.3 Error group 3: Device interlock

Code	Reason	Action
3 ; 1	Preparation at device interlock. Short circuit is missing from J6/7-8 on board NRRAD. It can be caused by a connected device.	Apply a short circuit to pins 7-8 of connector J6 of board NRRAD. If error still exists, replace NRRAD.

3.3.4 Error group 4: Door open

Code	Reason	Action
4 ; 1	Preparation when door is open. Short circuit is missing from J6/1-2 on board NRRAD. It can be caused by connected door switch.	Apply a short circuit to pins 1-2 of connector J6 of board NRRAD. If error still exists, replace NRRAD.

3.3.5 Error group 5: Preparation too long

Code	Reason	Action
5 ; 1	Maximum preparation time has elapsed on NRRAD board.	This time cannot be set in this generator. Please contact us.

3.3.6 Error group 6: Power supply fault

Code	Reason	Action
6 ; 1	Line input voltage is missing. Input voltage is missing on connector J9 of board NRRAD for 65ms. Generator is turned off.	If 230VAC voltage is OK on NRRAD/J9, then replace NRRAD.
6 ; 2	Line input voltage is missing. Input voltage is missing on connector J9 of board NRRAD at charging procedure (before turning RY1 main relay on).	Check fuse F9 in power input unit. If fuse is OK and 230VAC voltage is OK on NRRAD/J9, then replace NRRAD.
6 ; 3	+15V supply voltage is missing (on NRRAD).	• Check fuse F7 on NRRAD. If fuse blows after replacing it you can disconnect NRCON/J1, NRLHS/J3 from ribbon cable to check which board is faulty. • Check +15V supply voltage on pins J15/3-4 of NRRAD. If voltage is missing, replace power supply PS1.

Code	*Reason*	*Action*
6 ; 4	-15V supply voltage is missing (on NRRAD).	• Check fuse F8 on NRRAD. If fuse blows after replacing it you can disconnect NRCON/J1, NRLHS/J3 from ribbon cable to check which board is faulty. • Check -15V supply voltage on pins J15/5-4 of NRRAD. If voltage is missing, replace power supply PS1.
6 ; 5	+24V supply voltage is missing (on NRRAD).	• Check fuse F6 on NRRAD. If fuse blows after replacing it you can disconnect NRCON/J1, NRLHS/J3, NRAEC/J1, NRTUS/J7 to check which board is faulty. • Check +24V supply voltage on pins J15/1-2 of NRRAD. If voltage is missing, replace power supply PS2.
6 ; 6	+18V IF (interface) supply voltage is missing on NRRAD, because generator is turned off by "OFF" button on the console. Generator is turned off. This error is not logged.	If this error happens when generator is not turned off, replace NRRAD. See also chapter 3.1.2/3.

3.3.7 Error group 7: Filament fault (NRRAD)

Code	*Reason*	*Action*
7 ; 1	Filament current is low. Filament current is lower than 94% of the set value when filament current is below 5.5A.	• Turn generator off. Activate RY2 on power input unit for a moment with its button. Check that both LEDs LD16, LD17 *(HVDC OK)* are lit. If only one LED is lit, don't turn on generator because capacitors CE17, CE18 on NRRAD can explode! In this case replace NRRAD board. • Disconnect tube cathode from high voltage tank. Check with resistance meter that tube focal spots and high voltage cable are OK. • Connect a 230VAC lamp to J16/2,4 in case of small focal spot, or to J16/1,3 in case of large focal spot on NRRAD. If lamp is lit, replace high voltage tank. If lamp does not light, replace NRRAD board.
7 ; 2	Filament current is high. Filament current feedback is higher than 106% of the set value. Preparation is stopped.	Replace NRRAD board.
7 ; 3	Filament current is high and remains high.	Replace NRRAD board.

Code	*Reason*	*Action*
	Like 7 ; 2, but current remains high after stopping preparation.	
7 ; 4	Filament current is high. Filament current feedback is higher than the maximum value in tube parameters. Preparation is stopped.	Replace NRRAD board.
7 ; 5	Filament current is high and remains high. Like 7 ; 4, but current remains high after stopping preparation.	Replace NRRAD board.
7 ; 6	Set filament current is low. Reference filament current calculated by NRCON board is lower than the standby current in tube parameters.	Check tube insert settings (see chapter 4.3.2 of document *R-3241 Generator Setup*) and make a tube calibration (see chapter 3.3 of document *R-3241 Generator Setup*). If the problem still exists, please contact us.
7 ; 7	Set filament current is high. Reference filament current calculated by NRCON board is higher than the maximum filament current in tube parameters.	Like 7 ; 6.
7 ; 8	Like 7 ; 6.	
7 ; 9	Like 7 ; 7.	
7 ; 10	Filament protection fuse emulation alert. Fuse protection calculated that filament temperature is too high and preparation is stopped.	Check filament protection parameters (see chapter 4.3.2 of document *R-3241 Generator Setup*). If they are OK, it can caused by operator (e.g. too frequent preparation).
7 ; 11	Filament protection fuse emulation release. Like 7 ; 10, but overtemperature still remains after stopping preparation.	Like 7 ; 10.
7 ; 12	Filament current is too high during tube conditioning (>4A). At tube conditioning filament current is increased until set mA is reached. In this case set maximum filament current is reached before reaching mA because focal spot cannot emit current.	Check tube focal spot (measure resistance, etc.)
7 ; 13	Standby current is too high. Either passive or active standby	Check standby currents in tube insert settings (see chapter 4.3.2 of document

Code	Reason	Action
	current is above 4 A.	*R-3241 Generator Setup*).

3.3.8 Error group 8: Low speed starter fault

Code	Reason	Action
8 ; 1	Low current on main winding at boost. Output current at boost on main winding is lower than the set value for boost/brake in tube housing parameters.	Check resistance of the stator. Check settings in tube housing parameters (see chapters 4.4.2 and 4.4.4 of document *R-3241 Generator Setup*). If they are OK, replace NRRAD board.
8 ; 2	Low current on shift winding at boost. Output current at boost on shift winding is lower than the set value for boost/brake in tube housing parameters.	Like 8 ; 1.
8 ; 3	Low current on main and shift windings at boost. Output current at boost both on main and shift windings are lower than the set value for boost/brake in tube housing parameters.	Like 8 ; 1.
8 ; 4	Low current on main winding at run. Output current at run phase on main winding is lower than the set value for run in tube housing parameters.	Like 8 ; 1.
8 ; 5	Low current on shift winding at run. Output current at run phase on shift winding is lower than the set value for run in tube housing parameters.	Like 8 ; 1.
8 ; 6	Low current on main and shift windings at run. Output current at run phase both on main and shift windings are lower than the set value for run in tube housing parameters.	Like 8 ; 1.
8 ; 7	Low current on main winding at DC brake. Output current during DC brake on main winding is lower than the set value for boost/brake in tube housing parameters.	Like 8 ; 1.
8 ; 8	High current on shift winding at DC brake.	Like 8 ; 1.

Code	*Reason*	*Action*
	Output current at DC brake phase on shift winding is higher than the set value for run in tube housing parameters.	
8 ; 9	Current flows on main winding when there is no operation. Output current on main winding is higher than 0.8A in idle phase. It can happen if you connect stator when generator is on.	If it happens after power on, replace NRRAD board.
8 ; 10	Current flows on shift winding when there is no operation. Output current on shift winding is higher than 0.8A in idle phase. It can happen if you connect stator when generator is on.	Like 8 ; 9.
8 ; 11	Current flows on main and shift windings when there is no operation. Output current both on main and shift windings are higher than 0.8A in idle phase. It can happen if you connect stator when generator is on.	Like 8 ; 9.
8 ; 12	Boost time too high. Boost time for selected tube is higher than 3 s.	Check tube housing settings (see chapter 4.4.2 of document *R-3241 Generator Setup*).
8 ; 13	Boost time is too low. Boost time for selected tube is lower than 0.5 s.	Like 8 ; 12.
8 ; 14	Error in set rotor voltage. Run voltage code is higher or equal to half of boost voltage code.	Like 8 ; 12.
8 ; 15	Overcurrent on main winding. Output current peak is higher than 20A on main winding.	Like 8 ; 1.
8 ; 16	Overcurrent on shift winding. Output current peak is higher than 20A on shift winding.	Like 8 ; 1.
8 ; 17	Overcurrent on main and shift windings. Output current peak is higher than 20A both on main and shift windings.	Like 8 ; 1.

Code	*Reason*	*Action*
8 ; 18	Rotor protection fuse emulation alert (main winding). Rotor protection has calculated that winding temperature is too high and preparation is stopped.	Check rotor protection parameters (see chapter 4.4.4 of document *R-3241 Generator Setup*). If they are OK, it can caused by operator (e.g. too frequent preparation).
8 ; 19	Rotor protection fuse emulation release (main winding). Like 8, 18, but overtemperature still remains after stopping preparation.	Like 8 ; 18.
8 ; 20	Rotor protection fuse emulation alert (shift winding). Rotor protection has calculated that winding temperature is too high and preparation is stopped.	Like 8 ; 18.
8 ; 21	Rotor protection fuse emulation release (shift winding). Like 8, 20, but overtemperature still remains after stopping preparation.	Like 8 ; 18.

3.3.9 Error group 9: External device error

This error is sent by external device (e.g. PC of digital imaging system) through serial port of the console. See description of external device.

3.3.10 Error group 10: NRRAD database error

Code	*Reason*	*Action*
10 ; 1	Stack overflow on NRRAD.	Software problem, please contact us.
10 ; 3	Database ID is missing in E2PROM U21 on board NRRAD. E2PROM is missing or all data is lost.	Replace NRRAD board.
10 ; 4	Database version error in NRRAD database stored in U21.	Please contact us.
10 ; 5	Checksum error in NRRAD database stored in U21.	Please contact us.
10 ; 6	Test error for factory test.	Please contact us.
10 ; 16	Filament protection parameter error for tube 1. Filament fuse parameters are recalculated in NRRAD startup. During this overflow has occurred.	Change filament protection currents for tube 1 (see chapter 4.3.2 of document *R-3241 Generator Setup*).
10 ; 17	Filament protection parameter error	Change filament protection currents for

Code	*Reason*	*Action*
	for tube 2. Filament fuse parameters are recalculated in NRRAD startup. During this overflow has occurred.	tube 2 (see chapter 4.3.2 of document *R-3241 Generator Setup*).
10 ; 18	Filament protection parameter Imin too high for tube 1.	Change filament fuse minimal current for tube 1 (see chapter 4.3.2 of document *R-3241 Generator Setup*).
10 ; 19	Filament protection parameter Imin too high for tube 2.	Change filament fuse minimal current for tube 2 (see chapter 4.3.2 of document *R-3241 Generator Setup*).
10 ; 20	Low level parameter "full scale filament current" too high or too low.	Contact us for password to change value to 8.19 A.

3.3.12 Error group 12: NRRAD CAN error

Code	*Reason*	*Action*
12 ; 1	CAN message transmit error.	CAN communication or software problem. Please contact us.
12 ; 2	Like 12 ; 1.	Like 12 ; 1.
12 ; 3	Like 12 ; 1.	Like 12 ; 1.
12 ; 4	High speed starter communication has stopped.	Like 12 ; 1.
12 ; 7	NRCON board does not respond to NRRAD's request.	Like 12 ; 1.
12 ; 8	Like 12, 7.	Like 12 ; 1.
12 ; 15	CAN buffer is full on board NRRAD.	Like 12 ; 1.

3.3.13 Error group 13: NRRAD I2C error

Code	*Reason*	*Action*
13 ; 1	NRRAD E2PROM (U21) reading has failed.	Replace NRRAD.
13 ; 2	Like 13 ; 1.	Replace NRRAD.
13 ; 3	NRRAD E2PROM (U21) writing has failed.	Replace NRRAD.
13 ; 4	Like 13 ; 3.	Replace NRRAD.
13 ; 5	Like 13 ; 1.	Replace NRRAD.

Code	*Reason*	*Action*
13 ; 6	Like 13 ; 3.	Replace NRRAD.

3.3.15 Error group 15: Interrupted preparation

Code	*Reason*	*Action*
15	User interrupted preparation. User has released preparation button on device.	Check if button has contact fault.

3.3.16 Error group 16: Tube conditioning: filament current high

Code	*Reason*	*Action*
16 ; 1	Filament current is too high during tube conditioning. Filament current is increased automatically if the set value is higher than the feedback value. If filament current reaches 4 A, conditioning is stopped with this error.	Check if focal spot of the tube is correct.

3.3.17 Error group 17: Interrupted exposure

Code	*Reason*	*Action*
17 ; 1	User interrupted exposure. User has released exposure button on device during exposure.	Check if button has contact fault.

3.3.18 Error group 18: Max. fluoro time elapsed

Code	*Reason*	*Action*
18 ; 1	Fluoro exposure time counted on fluoro remote controller has reached maximum value set in service program. Fluoroscopy is terminated.	Check set value of maximum time with service program (see chapter 4.9.4 of document *R-3241 Generator Setup*). Reset fluoro timer with button **>0<** on fluoro remote controller.

3.3.19 Error group 19: Generator not ready for spot

Code	*Reason*	*Action*
19 ; 1	Generator does not supply ready signal (rotor ready, etc.) for spot exposure.	If it is not because of not proper user action, please contact us.

3.3.20 Error group 20: Tube HU overload

Code	*Reason*	*Action*
20 ; 1	Tube became too hot during fluoroscopy or spot exposures.	Please wait until tube cools down. Check tube insert and housing cooling curves and stator resistances (see chapters 4.3.4, 4.4.4, 4.4.5 of document *R-3241 Generator Setup*).

3.3.21 Error group 21: NRFIF communication or software error

Code	*Reason*	*Action*
21 ; 1	Database ID is missing from database of NRRAD.	Please contact us.
21 ; 2	Database version error on database of NRRAD.	Please contact us.
21 ; 3	Database checksum error on NRRAD.	Please contact us.
21 ; 4	Filament protection parameter error for tube 1. Filament fuse parameters are recalculated in NRFIF startup. During this overflow has occurred.	Change filament protection currents for tube 1 (see chapter 4.3.2 of document *R-3241 Generator Setup*).
21 ; 5	Filament protection parameter error for tube 2. Filament fuse parameters are recalculated in NRFIF startup. During this overflow has occurred.	Change filament protection currents for tube 2 (see chapter 4.3.2 of document *R-3241 Generator Setup*).
21 ; 6	CAN message transmit error.	CAN communication or software problem. Please contact us.
21 ; 7	Like 21 ; 6.	Like 21 ; 6.
21 ; 8	Like 21 ; 6.	Like 21 ; 6.
21 ; 9	CAN communication problem between NRCON and NRFIF.	Like 21 ; 6.
21 ; 10	Like 21 ; 9.	Like 21 ; 6.
21 ; 11	Like 21 ; 6.	Like 21 ; 6.
21 ; 12	CAN communication problem between NRRAD and NRFIF.	Like 21 ; 6.
21 ; 13	Like 21 ; 9.	Like 21 ; 6.
21 ; 14	Filament current calculated for exposure is too low.	Make tube calibration (see chapter 3.3 of document *R-3241 Generator Setup*).

Code	*Reason*	*Action*
21 ; 15	Filament current calculated for exposure is too high.	Like 21 ; 14.
21 ; 16	Like 21 ; 14.	Like 21 ; 14.
21 ; 17	Like 21 ; 15.	Like 21 ; 14.
21 ; 18	Filament current calculated for fluoroscopy is too low.	Make tube calibration for fluoroscopy (see chapter 3.3.3 of document *R-3241 Generator Setup*).
21 ; 19	Filament current calculated for fluoroscopy is too high.	Like 21 ; 18.
21 ; 20	Standby current is too high. Either passive or active standby current is above 4 A.	Check standby currents in tube insert settings (see chapter 4.3.2 of document *R-3241 Generator Setup*).
21 ; 21	Stack overflow.	Software problem. Please contact us.
21 ; 22	Preparation is not ready on NRRAD. (Rotor is not ready).	If not caused by not proper use of the generator, please contact us.
21 ; 23	Error occurred under getting configuration data from NRRAD through CAN bus.	Communication or software problem. Please contact us.
21 ; 24	Unable to write E2PROM of NRCON. Calibration points are temporary saved on E2PROM of board NRCON. During write error has occurred.	Communication or software problem. Please contact us.

3.3.22 Error group 22: NRFIF supply voltage fault

Code	*Reason*	*Action*
22 ; 1	+15V supply voltage is missing on board NRFIF.	• Check +15V supply voltage on pins 6 (+) and 5 (-) of connector *J7* on board NRFIF. If voltage is present, replace NRFIF. • Check voltage +15V on board NRRAD. If voltage is OK, replace ribbon cable between NRRAD and NRFIF.
22 ; 2	-15V supply voltage is missing on board NRFIF.	• Check -15V supply voltage on pins 20 (+) and 5 (-) of connector *J7* on board NRFIF. If voltage is present, replace NRFIF. • Check voltage -15V on board NRRAD. If voltage is OK, replace ribbon cable between NRRAD and NRFIF.

Code	*Reason*	*Action*
22 ; 3	+24V supply voltage is missing on board NRFIF.	• Check +24V supply voltage on pins 1 (+) and 5 (-) of connector *J7* on board NRFIF. If voltage is present, replace NRFIF. • Check voltage +24V on board NRRAD. If voltage is OK, replace ribbon cable between NRRAD and NRFIF.
22 ; 4	+24V interface supply voltage is missing on board NRFIF.	• Check interface supply voltage on pins 1 (+) and 2 (-) of connector *J1* on board NRFIF. Voltage should be between 12..30V. If voltage is present, replace NRFIF.

3.3.23 Error group 23: Filament fault (NRFIL)

Code	*Reason*	*Action*
23 ; 1	Filament current is low on small focal spot. Filament current is lower than 94% of the set value when filament current is below 5.5A.	• Turn generator off. Activate RY2 on power input unit for a moment with its button. Check that both LEDs LD1, LD2 *(HVDC OK)* are lit on board NRFIL. If only one LED is lit, don't turn on generator because capacitors CE1, CE2 on NRFIL can explode! In this case replace NRFIL board. • Disconnect tube cathode from high voltage tank. Check with resistance meter that tube focal spots and high voltage cable are OK. • Connect a 230VAC lamp to J4/1,2 on NRFIL. If lamp is lit, replace high voltage tank. • Check control signals -*FILDA LD, -FILDA CLR, FILDA CLK, FILDA SDI* with oscilloscope on connector J3 of board NRFIL (see chapter 2.4.2) after power on. If the signal does not change at all, replace NRFIF or ribbon cable, otherwise replace board NRFIL.
23 ; 2	Filament current is high. Filament current feedback is higher than 106% of the set value. Preparation is stopped.	Replace NRFIL board.
23 ; 3	Filament current is high and remains high. Like 23 ; 2, but current remains high after stopping preparation.	Replace NRFIL board.

Code	*Reason*	*Action*
23 ; 4	Filament current is high. Filament current feedback is higher than the maximum value in tube parameters. Preparation is stopped.	Replace NRFIL board.
23 ; 5	Filament current is high and remains high. Like 23 ; 4, but current remains high after stopping preparation.	Replace NRFIL board.
23 ; 6	Filament protection fuse emulation alert. Fuse protection calculated that filament temperature is too high and preparation is stopped.	Check filament protection parameters (see chapter 4.3.2 of document *R-3241 Generator Setup*). If they are OK, it can caused by operator (e.g. too frequent preparation).
23 ; 7	Filament protection fuse emulation release. Like 23 ; 6, but overtemperature still remains after stopping preparation.	Like 23 ; 6.

3.3.25 Error group 25: Beam fault

Code	*Reason*	*Action*
25	Hardware protection has stopped exposure on NRCON. Reason is coded in error code 'detailed'. If more protections are active, their 'detailed' codes are added, e.g.: 25 ; 96 = 25 ; 32 + 25 ; 64	Check from error code which protections are active. See action for each protections below.
25 ; 1	kV asymmetry on anode side. kV on anode side of the tube is about 35kV lower than on cathode side.	See tips below. If it is not caused by of high voltage arc, measure kV feedback signals with oscilloscope on connector J3 of high voltage tank: kV(anode): J3/5-1, kV(cathode): J3/4-1 (150kV=12.78V). If there is asymmetry, replace high voltage tank, otherwise replace board NRCON.
25 ; 2	kV asymmetry on cathode side. kV on cathode side of the tube is about 35kV lower than on anode side.	Like 25 ; 1.
25 ; 4	Inverter error. Error signal from board HFIIB because capacitor bank voltage is low, inverter overcurrent or IGBT overcurrent.	Check which error is present on board HFIIB (see chapter 2.4.3). See tips below.

Code	*Reason*	*Action*
25 ; 8	Invalid AEC termination. AEC stop signal received when AEC was not started.	Can be a noise problem. Please contact us.
25 ; 16	Supply voltage is missing (on NRCON). One of following supply voltages is missing or low on board NRCON: +15V, -15V, +5V, -5V, +10V, isolated +5V for CAN2	Check voltages on connector J1 of board NRCON: +5V on J1/13-12 +15V on J1/6-5 -15V on J1/18-17 If these values are OK, replace NRCON. If voltages are missing, check voltages on board NRRAD.
25 ; 32	High voltage arc on anode side. Anode side current is above 1385 mA.	See tips below.
25 ; 64	High voltage arc on cathode side. Anode side current is above 1385 mA.	See tips below.
25;128	kV is too high. Output kV on tube is above 175 kV.	Replace NRCON.
25;256	Fatal inverter error. Error signal from board HFIIB: can be because of capacitor bank overvoltage or asymmetry, IGBT driver error, IGBT or high voltage tank overheating. Generator operation is inhibited until power off.	Check which error is present on board HFIIB (see chapter 2.4.3).

You can decode error code with the following table:

Code	1: Asymmetry +	2: Asymmetry -	4: Inverter error	8: AEC	16: Power	32: Arc +	64: Arc -	128: kV over	256: Fatal inv. e.	Code	1: Asymmetry +	2: Asymmetry -	4: Inverter errpr	8: AEC	16: Power	32: Arc +	64: Arc -	128: kV over	256: Fatal inv. e.	Code	1: Asymmetry +	2: Asymmetry -	4: Inverter errpr	8: AEC	16: Power	32: Arc +	64: Arc -	128: kV over	256: Fatal inv. e.	Code	1: Asymmetry +	2: Asymmetry -	4: Inverter errpr	8: AEC	16: Power	32: Arc +	64: Arc -	128: kV over	256: Fatal inv. e.
1	●									129	●							●		257	●								●	385	●								
2		●								130		●						●		258		●							●	386		●						●	●
3	●	●								131	●	●						●		259	●	●							●	387	●	●						●	●
4			●							132			●					●		260			●						●	388			●					●	●
5	●		●							133	●		●					●		261	●		●						●	389	●		●					●	●
6		●	●							134		●	●					●		262		●	●						●	390		●	●					●	●
7	●	●	●							135	●	●	●					●		263	●	●	●						●	391	●	●	●					●	●
8				●						136				●				●		264				●					●	392				●				●	●
9	●			●						137	●			●				●		265	●			●					●	393	●			●				●	●
10		●		●						138		●		●				●		266		●		●					●	394		●		●				●	●
11	●	●		●						139	●	●		●				●		267	●	●		●					●	395	●	●		●				●	●
12			●	●						140			●	●				●		268			●	●					●	396			●	●				●	●
13	●		●	●						141	●		●	●				●		269	●		●	●					●	397	●		●	●				●	●

Code	1: Asymmetry +	2: Asymmetry -	4: Inverter error	8: AEC	16: Power	32: Arc +	64: Arc -	128: kV over	256: Fatal inv. e.
14		●	●	●					
15	●	●	●	●					
16					●				
17	●				●				
18		●			●				
19	●	●			●				
20			●		●				
21	●		●		●				
22		●	●		●				
23	●	●	●		●				
24				●	●				
25	●			●	●				
26		●		●	●				
27	●	●		●	●				
28			●	●	●				
29	●		●	●	●				
30		●	●	●	●				
31	●	●	●	●	●				
32						●			
33	●					●			
34		●				●			
35	●	●				●			
36			●			●			
37	●		●			●			
38		●	●			●			
39	●	●	●			●			
40				●		●			
41	●			●		●			
42		●		●		●			
43	●	●		●		●			
44			●	●		●			
45	●		●	●		●			
46		●	●	●		●			
47	●	●	●	●		●			
48					●	●			
49	●				●	●			
50		●			●	●			
51	●	●			●	●			
52			●		●	●			
53	●		●		●	●			
54		●	●		●	●			
55	●	●	●		●	●			
56				●	●	●			
57	●			●	●	●			
58		●		●	●	●			
59	●	●		●	●	●			
60			●	●	●	●			

Code	1: Asymmetry +	2: Asymmetry -	4: Inverter errpr	8: AEC	16: Power	32: Arc +	64: Arc -	128: kV over	256: Fatal inv. e.
142		●	●	●				●	
143	●	●	●	●				●	
144					●			●	
145	●				●			●	
146		●			●			●	
147	●	●			●			●	
148			●		●			●	
149	●		●		●			●	
150		●	●		●			●	
151	●	●	●		●			●	
152				●	●			●	
153	●			●	●			●	
154		●		●	●			●	
155	●	●		●	●			●	
156			●	●	●			●	
157	●		●	●	●			●	
158		●	●	●	●			●	
159	●	●	●	●	●			●	
160						●		●	
161	●					●		●	
162		●				●		●	
163	●	●				●		●	
164			●			●		●	
165	●		●			●		●	
166		●	●			●		●	
167	●	●	●			●		●	
168				●		●		●	
169	●			●		●		●	
170		●		●		●		●	
171	●	●		●		●		●	
172			●	●		●		●	
173	●		●	●		●		●	
174		●	●	●		●		●	
175	●	●	●	●		●		●	
176					●	●		●	
177	●				●	●		●	
178		●			●	●		●	
179	●	●			●	●		●	
180			●		●	●		●	
181	●		●		●	●		●	
182		●	●		●	●		●	
183	●	●	●		●	●		●	
184				●	●	●		●	
185	●			●	●	●		●	
186		●		●	●	●		●	
187	●	●		●	●	●		●	
188			●	●	●	●		●	

Code	1: Asymmetry +	2: Asymmetry -	4: Inverter errpr	8: AEC	16: Power	32: Arc +	64: Arc -	128: kV over	256: Fatal inv. e.
270		●	●	●					●
271	●	●	●	●					●
272					●				●
273	●				●				●
274		●			●				●
275	●	●			●				●
276			●		●				●
277	●		●		●				●
278		●	●		●				●
279	●	●	●		●				●
280				●	●				●
281	●			●	●				●
282		●		●	●				●
283	●	●		●	●				●
284			●	●	●				●
285	●		●	●	●				●
286		●	●	●	●				●
287	●	●	●	●	●				●
288						●			●
289	●					●			●
290		●				●			●
291	●	●				●			●
292			●			●			●
293	●		●			●			●
294		●	●			●			●
295	●	●	●			●			●
296				●		●			●
297	●			●		●			●
298		●		●		●			●
299	●	●		●		●			●
300			●	●		●			●
301	●		●	●		●			●
302		●	●	●		●			●
303	●	●	●	●		●			●
304					●	●			●
305	●				●	●			●
306		●			●	●			●
307	●	●			●	●			●
308			●		●	●			●
309	●		●		●	●			●
310		●	●		●	●			●
311	●	●	●		●	●			●
312				●	●	●			●
313	●			●	●	●			●
314		●		●	●	●			●
315	●	●		●	●	●			●
316			●	●	●	●			●

Code	1: Asymmetry +	2: Asymmetry -	4: Inverter errpr	8: AEC	16: Power	32: Arc +	64: Arc -	128: kV over	256: Fatal inv. e.
398		●	●	●				●	●
399	●	●	●	●				●	●
400					●			●	●
401	●				●			●	●
402		●			●			●	●
403	●	●			●			●	●
404			●		●			●	●
405	●		●		●			●	●
406		●	●		●			●	●
407	●	●	●		●			●	●
408				●	●			●	●
409	●			●	●			●	●
410		●		●	●			●	●
411	●	●		●	●			●	●
412			●	●	●			●	●
413	●		●	●	●			●	●
414		●	●	●	●			●	●
415	●	●	●	●	●			●	●
416						●		●	●
417	●					●		●	●
418		●				●		●	●
419	●	●				●		●	●
420			●			●		●	●
421	●		●			●		●	●
422		●	●			●		●	●
423	●	●	●			●		●	●
424				●		●		●	●
425	●			●		●		●	●
426		●		●		●		●	●
427	●	●		●		●		●	●
428			●	●		●		●	●
429	●		●	●		●		●	●
430		●	●	●		●		●	●
431	●	●	●	●		●		●	●
432					●	●		●	●
433	●				●	●		●	●
434		●			●	●		●	●
435	●	●			●	●		●	●
436			●		●	●		●	●
437	●		●		●	●		●	●
438		●	●		●	●		●	●
439	●	●	●		●	●		●	●
440				●	●	●		●	●
441	●			●	●	●		●	●
442		●		●	●	●		●	●
443	●	●		●	●	●		●	●
444			●	●	●	●		●	●

Code	1: Asymmetry +	2: Asymmetry -	4: Inverter error	8: AEC	16: Power	32: Arc +	64: Arc -	128: kV over	256: Fatal inv. e.
61	●		●	●	●	●			
62		●	●	●	●	●			
63	●	●	●	●	●	●			
64							●		
65	●						●		
66		●					●		
67	●	●					●		
68			●				●		
69	●		●				●		
70		●	●				●		
71	●	●	●				●		
72				●			●		
73	●			●			●		
74		●		●			●		
75	●	●		●			●		
76			●	●			●		
77	●		●	●			●		
78		●	●	●			●		
79	●	●	●	●			●		
80					●		●		
81	●				●		●		
82		●			●		●		
83	●	●			●		●		
84			●		●		●		
85	●		●		●		●		
86		●	●		●		●		
87	●	●	●		●		●		
88				●	●		●		
89	●			●	●		●		
90		●		●	●		●		
91	●	●		●	●		●		
92			●	●	●		●		
93	●		●	●	●		●		
94		●	●	●	●		●		
95	●	●	●	●	●		●		
96						●	●		
97	●					●	●		
98		●				●	●		
99	●	●				●	●		
100			●			●	●		
101	●		●			●	●		
102		●	●			●	●		
103	●	●	●			●	●		
104				●		●	●		
105	●			●		●	●		
106		●		●		●	●		
107	●	●		●		●	●		

Code	1: Asymmetry +	2: Asymmetry -	4: Inverter errpr	8: AEC	16: Power	32: Arc +	64: Arc -	128: kV over	256: Fatal inv. e.
189	●		●	●	●	●		●	
190		●	●	●	●	●		●	
191	●	●	●	●	●	●		●	
192							●	●	
193	●						●	●	
194		●					●	●	
195	●	●					●	●	
196			●				●	●	
197	●		●				●	●	
198		●	●				●	●	
199	●	●	●				●	●	
200				●			●	●	
201	●			●			●	●	
202		●		●			●	●	
203	●	●		●			●	●	
204			●	●			●	●	
205	●		●	●			●	●	
206		●	●	●			●	●	
207	●	●	●	●			●	●	
208					●		●	●	
209	●				●		●	●	
210		●			●		●	●	
211	●	●			●		●	●	
212			●		●		●	●	
213	●		●		●		●	●	
214		●	●		●		●	●	
215	●	●	●		●		●	●	
216				●	●		●	●	
217	●			●	●		●	●	
218		●		●	●		●	●	
219	●	●		●	●		●	●	
220			●	●	●		●	●	
221	●		●	●	●		●	●	
222		●	●	●	●		●	●	
223	●	●	●	●	●		●	●	
224						●	●	●	
225	●					●	●	●	
226		●				●	●	●	
227	●	●				●	●	●	
228			●			●	●	●	
229	●		●			●	●	●	
230		●	●			●	●	●	
231	●	●	●			●	●	●	
232				●		●	●	●	
233	●			●		●	●	●	
234		●		●		●	●	●	
235	●	●		●		●	●	●	

Code	1: Asymmetry +	2: Asymmetry -	4: Inverter errpr	8: AEC	16: Power	32: Arc +	64: Arc -	128: kV over	256: Fatal inv. e.
317	●		●	●	●	●			●
318		●	●	●	●	●			●
319	●	●	●	●	●	●			●
320							●		●
321	●						●		●
322		●					●		●
323	●	●					●		●
324			●				●		●
325	●		●				●		●
326		●	●				●		●
327	●	●	●				●		●
328				●			●		●
329	●			●			●		●
330		●		●			●		●
331	●	●		●			●		●
332			●	●			●		●
333	●		●	●			●		●
334		●	●	●			●		●
335	●	●	●	●			●		●
336					●		●		●
337	●				●		●		●
338		●			●		●		●
339	●	●			●		●		●
340			●		●		●		●
341	●		●		●		●		●
342		●	●		●		●		●
343	●	●	●		●		●		●
344				●	●		●		●
345	●			●	●		●		●
346		●		●	●		●		●
347	●	●		●	●		●		●
348			●	●	●		●		●
349	●		●	●	●		●		●
350		●	●	●	●		●		●
351	●	●	●	●	●		●		●
352						●	●		●
353	●					●	●		●
354		●				●	●		●
355	●	●				●	●		●
356			●			●	●		●
357	●		●			●	●		●
358		●	●			●	●		●
359	●	●	●			●	●		●
360				●		●	●		●
361	●			●		●	●		●
362		●		●		●	●		●
363	●	●		●		●	●		●

Code	1: Asymmetry +	2: Asymmetry -	4: Inverter errpr	8: AEC	16: Power	32: Arc +	64: Arc -	128: kV over	256: Fatal inv. e.
445	●		●	●	●	●			●
446		●	●	●	●	●			●
447	●	●	●	●	●	●			●
448							●		●
449	●						●		●
450		●					●		●
451	●	●					●		●
452			●				●		●
453	●		●				●		●
454		●	●				●		●
455	●	●	●				●		●
456				●			●		●
457	●			●			●		●
458		●		●			●		●
459	●	●		●			●		●
460			●	●			●		●
461	●		●	●			●		●
462		●	●	●			●		●
463	●	●	●	●			●		●
464					●		●		●
465	●				●		●		●
466		●			●		●		●
467	●	●			●		●		●
468			●		●		●		●
469	●		●		●		●		●
470		●	●		●		●		●
471	●	●	●		●		●		●
472				●	●		●		●
473	●			●	●		●		●
474		●		●	●		●		●
475	●	●		●	●		●		●
476			●	●	●		●		●
477	●		●	●	●		●		●
478		●	●	●	●		●		●
479	●	●	●	●	●		●		●
480						●	●		●
481	●					●	●		●
482		●				●	●		●
483	●	●				●	●		●
484			●			●	●		●
485	●		●			●	●		●
486		●	●			●	●		●
487	●	●	●			●	●		●
488				●		●	●		●
489	●			●		●	●		●
490		●		●		●	●		●
491	●	●		●		●	●		●

Code	1: Asymmetry +	2: Asymmetry -	4: Inverter error	8: AEC	16: Power	32: Arc +	64: Arc -	128: kV over	256: Fatal inv. e.
108			●	●		●	●		
109	●		●	●		●	●		
110		●	●	●		●	●		
111	●	●	●	●		●	●		
112					●	●	●		
113	●				●	●	●		
114		●			●	●	●		
115	●	●			●	●	●		
116			●		●	●	●		
117	●		●		●	●	●		
118		●	●		●	●	●		
119	●	●	●		●	●	●		
120				●	●	●	●		
121	●			●	●	●	●		
122		●		●	●	●	●		
123	●	●		●	●	●	●		
124			●	●	●	●	●		
125	●		●	●	●	●	●		
126		●	●	●	●	●	●		
127	●	●	●	●	●	●	●		
128								●	

Code	1: Asymmetry +	2: Asymmetry -	4: Inverter errpr	8: AEC	16: Power	32: Arc +	64: Arc -	128: kV over	256: Fatal inv. e.
236			●	●		●	●	●	
237	●		●	●		●	●	●	
238		●	●	●		●	●	●	
239	●	●	●	●		●	●	●	
240					●	●	●	●	
241	●				●	●	●	●	
242		●			●	●	●	●	
243	●	●			●	●	●	●	
244			●		●	●	●	●	
245	●		●		●	●	●	●	
246		●	●		●	●	●	●	
247	●	●	●		●	●	●	●	
248				●	●	●	●	●	
249	●			●	●	●	●	●	
250		●		●	●	●	●	●	
251	●	●		●	●	●	●	●	
252			●	●	●	●	●	●	
253	●		●	●	●	●	●	●	
254		●	●	●	●	●	●	●	
255	●	●	●	●	●	●	●	●	
256									●

Code	1: Asymmetry +	2: Asymmetry -	4: Inverter errpr	8: AEC	16: Power	32: Arc +	64: Arc -	128: kV over	256: Fatal inv. e.
364			●	●		●	●		●
365	●		●	●		●	●		●
366		●	●	●		●	●		●
367	●	●	●	●		●	●		●
368					●	●	●		●
369	●				●	●	●		●
370		●			●	●	●		●
371	●	●			●	●	●		●
372			●		●	●	●		●
373	●		●		●	●	●		●
374		●	●		●	●	●		●
375	●	●	●		●	●	●		●
376				●	●	●	●		●
377	●			●	●	●	●		●
378		●		●	●	●	●		●
379	●	●		●	●	●	●		●
380			●	●	●	●	●		●
381	●		●	●	●	●	●		●
382		●	●	●	●	●	●		●
383	●	●	●	●	●	●	●		●
384								●	●

Code	1: Asymmetry +	2: Asymmetry -	4: Inverter errpr	8: AEC	16: Power	32: Arc +	64: Arc -	128: kV over	256: Fatal inv. e.
492			●	●		●	●	●	●
493	●		●	●		●	●	●	●
494		●	●	●		●	●	●	●
495	●	●	●	●		●	●	●	●
496					●	●	●	●	●
497	●				●	●	●	●	●
498		●			●	●	●	●	●
499	●	●			●	●	●	●	●
500			●		●	●	●	●	●
501	●		●		●	●	●	●	●
502		●	●		●	●	●	●	●
503	●	●	●		●	●	●	●	●
504				●	●	●	●	●	●
505	●			●	●	●	●	●	●
506		●		●	●	●	●	●	●
507	●	●		●	●	●	●	●	●
508			●	●	●	●	●	●	●
509	●		●	●	●	●	●	●	●
510		●	●	●	●	●	●	●	●
511	●	●	●	●	●	●	●	●	●

Tips for detecting which component is faulty in case of a high voltage arc:

- In case of a high voltage arc usually "high voltage arc" protections (32, 64, or both: 96) turn on. Furthermore the following errors can happen: kV asymmetry (1, 2, or both: 3), inverter error (4): inverter overcurrent, IGBT overcurrent.
- If high voltage arc error is independent from kV (also present on low kVs), then maybe error is caused by noise. Check impedance of protective earth. If you have no success, please contact us.
- If there is high voltage arc (or kV asymmetry) in both sides (anode and cathode), or sometimes on anode, sometimes on cathode side, arc is likely to be inside the X-ray tube. Try to make a tube conditioning to absorb gas in tube by warm anode (see chapter 3.1 of document *R-3241 Generator setup*).
- If there is high voltage arc only on one side (anode or cathode), in a two-tube system swap tubes (tube 1 and tube 2) at the high voltage tank. If arc still exists on the same selected tube, replace high voltage tank.
- If there is high voltage arc only on one side (anode or cathode), swap high voltage cables between anode and cathode. If arc is on the other side after change, replace high voltage cables.
- If there is high voltage arc only on one side (anode or cathode), and it is not caused by high voltage cables, and if kV asymmetry also presents, arc can be in high voltage tank.

3.3.28 Error group 28: High speed starter fault

Code	*Reason*	*Action*
28 ; 1	Low current on main winding at boost. Output current at boost on main winding is lower than the set value for boost/brake in tube housing parameters.	Check resistance of the stator. Check settings in tube housing parameters (see chapters 4.4.3 and 4.4.4 of document *R-3241 Generator Setup*). If they are OK, replace NRLHS board.
28 ; 2	Low current on shift winding at boost. Output current at boost on shift winding is lower than the set value for boost/brake in tube housing parameters.	Like 28 ; 1.
28 ; 3	Low current on main and shift windings at boost. Output current at boost both on main and shift windings is lower than the set value for boost/brake in tube housing parameters.	Like 28 ; 1.
28 ; 4	Low current on main winding at run. Output current at run phase on main winding is lower than the set value for run in tube housing parameters.	Like 28 ; 1.
28 ; 5	Low current on shift winding at run. Output current at run phase on shift winding is lower than the set value for run in tube housing parameters.	Like 28 ; 1.
28 ; 6	Low current on main and shift windings at run. Output current at run phase both on main and shift windings is lower than the set value for run in tube housing parameters.	Like 28 ; 1.
28 ; 7	Low current on main winding at DC brake. Output current during DC brake on main winding is lower than the set value for boost/brake in tube housing parameters.	Like 28 ; 1.
28 ; 8	High current on shift winding at DC brake. Output current at DC brake phase on shift winding is higher than the set value for run in tube housing parameters.	Like 28 ; 1.

Code	*Reason*	*Action*
28 ; 9	Current flows on main winding when there is no operation. Output current on main winding in idle phase is higher than the set value for run in tube housing parameters.	Replace NRLHS board.
28 ; 10	Current flows on shift winding when there is no operation. Output current on shift winding in idle phase is higher than the set value for run in tube housing parameters.	Replace NRLHS board.
28 ; 11	Current flows on main and shift windings when there is no operation. Output current both on main and shift windings in idle phase is higher than the set value for run in tube housing parameters.	Replace NRLHS board.
28 ; 12	Overcurrent on main winding. Output current peak is higher than 40A on main winding.	Like 28 ; 1.
28 ; 13	Overcurrent on shift winding. Output current peak is higher than 40A on shift winding.	Like 28 ; 1.
28 ; 14	Overcurrent on main and shift windings. Output current peak is higher than 40A both on main and shift windings.	Like 28 ; 1.
28 ; 15	Rotor protection fuse emulation alert (main winding). Rotor protection has calculated that winding temperature is too high and preparation is stopped.	Check rotor protection parameters (see chapter 4.4.4 of document *R-3241 Generator Setup*). If they are OK, it can caused by operator (e.g. too frequent preparation).
28 ; 16	Rotor protection fuse emulation release (main winding). Like 28 ; 16, but overtemperature still remains after stopping preparation.	Like 28 ; 15.
28 ; 17	Rotor protection fuse emulation alert (shift winding). Rotor protection calculated that winding temperature is too high and preparation is stopped.	Like 28 ; 15.

Code	*Reason*	*Action*
28 ; 18	Rotor protection fuse emulation release (shift winding). Like 28 ; 17, but overtemperature still remains after stopping preparation.	Like 28 ; 15.
28 ; 19	NRLHS IGBT is too hot.	Check temperature of heatsinks of NRLHS IGBTs Q1-Q4. If it is below 80°C, then replace NRLHS board.
28 ; 20	NRLHS IGBT overcurrent. Hardware overcurrent protection has detected IGBT current higher than 60A. Further operation is inhibited until turning off of the generator.	Disconnect tube stator from output of the high speed starter. If error still exists, replace NRLHS board.
28 ; 21	High speed preparation while high speed is not allowed for selected tube.	Check in generator configuration settings whether high speed starter is allowed for selected tube (see chapter 4.9.1 of document *R-3241 Generator Setup*). If configuration is OK, please contact us.
28 ; 22	560V DC input voltage on board NRLHS is missing at preparation. DC input voltage of NRLHS board is below 300V.	Check input voltage on NRLHS/J5-J6. If voltage is missing, check fuses on board TXFAA. If voltage is OK, then replace NRLHS.
28 ; 23	Rotor protection parameter error for main winding of tube 1. Rotor fuse parameters are recalculated in NRLHS startup. During this overflow has occurred.	Change stator protection currents (see chapter 4.4.4 of document *R-3241 Generator Setup*).
28 ; 24	Rotor protection parameter error for shift winding of tube 1. Rotor fuse parameters are recalculated in NRLHS startup. During this overflow has occurred.	Like 28 ; 23.
28 ; 25	Rotor protection parameter error for main winding of tube 2. Rotor fuse parameters are recalculated in NRLHS startup. During this overflow has occurred.	Like 28 ; 23.
28 ; 26	Rotor protection parameter error for shift winding of tube 2. Rotor fuse parameters are recalculated in NRLHS startup. During this overflow has occurred.	Like 28 ; 23.

Code	*Reason*	*Action*
28 ; 27	Rotation speed is low after low speed boost. If speed control is on, measured rotor speed is below the set level after low speed boost.	Check rotor speed by measuring frequency with storage oscilloscope on test point TP1 (*SPEED FREQ. FB.)* of board NRLHS. If there is no signal, connect oscilloscope to NRLHS/TP8 *(SPEED)* and while there is no preparation but anode is rotating turn potentiometer NRLHS/P1 to get a right speed signal (if you turn clockwise, sensitivity decreases). Be careful if you turn it too low, you may sense noise, not a signal from rotation. If you can't get a signal which has a slightly decreasing frequency (while rotor speed decreases) then turn speed control off (see chapter 4.4.3 of document *R-3241 Generator Setup*). If rotation signal is OK, check settings of speed control (see chapter 4.4.3 of document *R-3241 Generator Setup*).
28 ; 28	Rotation speed is low after high speed boost. If speed control is on, measured rotor speed is below the set level after high speed boost.	Like 28 ; 27.
28 ; 29	+15V supply voltage is missing (on NRLHS).	Check +15V voltage on pins J3/6-4 of board NRLHS. If voltage is OK, replace NRLHS board. If voltage is missing, check ribbon cable and +15V voltage on board NRRAD.
28 ; 30	-15V supply voltage is missing (on NRLHS).	Check -15V voltage on pins J3/18-16 of board NRLHS. If voltage is OK, replace NRLHS board. If voltage is missing, check ribbon cable and -15V voltage on board NRRAD.
28 ; 31	+24V supply voltage is missing (on NRLHS).	Check +24V voltage on pins J3/2-4 of board NRLHS. If voltage is OK, replace NRLHS board. If voltage is missing, check ribbon cable and +24V voltage on board NRRAD.
28 ; 32	Stack overflow on NRLHS.	Software problem, please contact us.
28 ; 33	CAN communication from NRRAD has stopped.	CAN communication or software problem, please contact us.
28 ; 34	Boost or brake time is too high. Some low speed, high speed boost or AC brake times for any tube are higher than 3s.	Check boost and brake times for both tubes (see chapter 4.4.3 of document *R-3241 Generator Setup*). If they are OK, please contact us.

Code	*Reason*	*Action*
28 ; 35	DC brake time is high. DC brake time for any tube is higher than 5s.	Check DC brake times for both tubes (see chapter 4.4.3 of document *R-3241 Generator Setup*). If they are OK, please contact us.
28 ; 36	Database reading has failed. NRLHS could not read starter parameters from board NRRAD via CAN bus at startup.	CAN communication or software problem, please contact us.
28 ; 37	Boost or brake voltage low. LS boost voltage, HS boost voltage or AC brake voltage for any tube is lower than 100V.	Check boost and brake voltage values in service program (see chapter 4.4.2 and 4.4.3 in document *R-3241 Generator Setup*).

3.3.32 Error group 32: Output kV low

Code	*Reason*	*Action*
32	Output feedback kV is below 10 kV.	See error group 39.

3.3.33 Error group 33: Capacitor undervoltage

Code	*Reason*	*Action*
33	Voltage of capacitor bank is low. Voltage of capacitor bank is lower than about 420VDC.	Measure line voltage to check if it's too low. Operate relay RY2 in power input unit with its button for a moment. Check way of capacitor bank voltage signal: capacitor bank, HFIIB/S5/1-5, HFIIB/S12/1-GND, NRCON/J2/1-14. Replace board or cable where signal disappears.

3.3.34 Error group 34: Output kV high

Code	*Reason*	*Action*
34	Output kV on tube is 10kV more than the set value.	Check that protective earth of generator is connected properly. Can be caused by noise. Replace board NRCON.

3.3.35 Error group 35: Bucky not ready

Code	*Reason*	*Action*
35	Ready signal from bucky is not present after 5 seconds after pushing EXP button on console.	Check whether bucky start signal can be detected. If not, replace NRRAD. Check whether ready signal from bucky is present. If it exists, replace NRRAD.

3.3.37 Error group 37: Tomo backup time elapsed

Code	*Reason*	*Action*
37	Set time of tomographic exposure is elapsed before disappearing 'ready' signal from table.	Set higher backup time for tomographic exposure in anatomical program. Check settings of tomographic device (see chapter 4.5.2 of document *R-3241 Generator setup*).

3.3.38 Error group 38: NRCON uncalibrated feedback

Code	*Reason*	*Action*
38	Feedback calibration data is missing from E2PROM of board NRCON.	Replace NRCON.

3.3.39 Error group 39: No output kV

Code	*Reason*	*Action*
39	Output kV on tube is lower than 75% of the set value after 3 ms for radiographic, or after 300 ms for fluoroscopic exposure.	In generator has fluoro option, check that NRFIF/J12 is connected to NRCON/J7. Check whether there is high voltage arc in the tube. Check IGBTs, IGBT drive signals, thyristors, thyristor drive signals, high voltage tank.

3.3.40 Error group 40: NRRAD communication error

Code	*Reason*	*Action*
40	Fatal communication error between NRRAD and NRCON. Generator is turned off.	Communication or software problem. Please contact us.

3.3.41 Error group 41: Charging fault

Code	*Reason*	*Action*
41	Voltage on capacitor bank is low during charging procedure. Voltage of capacitor bank is lower than 6V at charging after 0.5s, or voltage does not reach 350V (400VAC mains) or 230V (240VAC mains) in 1 minute, or voltage is not stable after 1 minute.	Check fuses F4, F5, F10 and resistors R1, R2, R4 in power input unit. See also chapter 3.3.33.

3.3.42 Error group 42: NRRAD communication error

Code	*Reason*	*Action*
42	Fatal communication error between NRRAD and NRCON at error. Generator is turned off.	Communication or software problem. Please contact us.

3.3.43 Error group 43: NRRAD communication error

Code	*Reason*	*Action*
43	Fatal communication error between NRRAD and NRCON during charging.	Communication or software problem. Please contact us.

3.3.44 Error group 44: NRRAD communication error

Code	*Reason*	*Action*
44	Fatal communication error between NRRAD and NRCON after charging.	Communication or software problem. Please contact us.

3.3.46 Error group 46: NRRAD communication error

Code	*Reason*	*Action*
46	Fatal communication error between NRRAD and NRCON during device selection on console.	Communication or software problem. Please contact us.

3.3.47 Error group 47: AEC backup mAs termination

Code	*Reason*	*Action*
47	Exposure is stopped at a 3-point mode exposure with AEC, because measured mAs reached 1.5 times the set value.	Check exposure parameters. Check AEC calibration. Check accuracy of tube calibration.

3.3.48 Error group 48: kV out of limits

Code	*Reason*	*Action*
48	Set kV is lower or higher than generator limits.	Check anatomical program. Check generator limits (see chapter 4.9.1 of document *R-3241 Generator setup*). Generator absolute limits are stored in NRCON, you cannot modify them.

3.3.49 Error group 49: Select bucky for Trixell calibration!

Code	*Reason*	*Action*
49	At Trixell calibration mode bucky cannot be started, because it is not configured to the selected device.	Select proper device on the console. Modify device configuration (see chapter 4.5.2 of document *R-3241 Generator setup*).

3.3.50 Error group 50: Trixell not ready at calibration

Code	*Reason*	*Action*
50	At Trixell calibration mode bucky ready signal is not present after 30 s timeout.	Check ready signal from bucky and Trixell controller PC.

3.3.51 Error group 51: Interrupted preparation

Code	*Reason*	*Action*
51	User has interrupted preparation. User has released PREP button of the console before exposure.	Check if button has contact fault.

3.3.52 Error group 52: NRRAD communication error

Code	*Reason*	*Action*
52	Fatal communication error between NRRAD and NRCON at the end of exposure. Generator is turned off.	Communication or software problem. Please contact us.

3.3.53 Error group 53: Rotor boost timeout

Code	*Reason*	*Action*
53	There is no rotor ready signal from NRRAD or NRLHS 5 seconds after start of preparation.	Check rotor starter parameters (see chapters 4.4.2, 4.4.3 of document *R-3241 Generator setup*). In high speed starter system if speed control is turned on, check that rotor speed is reached after rotor boost. In high speed starter system check CAN bus according to chapter 3.1.2 / 2. If CAN bus is proved to be OK, replace NRLHS board.

3.3.54 Error group 54: NRRAD communication error

Code	*Reason*	*Action*
54	Fatal communication error between NRRAD and NRCON during turning	Communication or software problem. Please contact us.

Code	Reason	Action
	off main relay RY1. Generator is turned off.	

3.3.55 Error group 55: Generator too hot

Code	Reason	Action
55	Temperature sensor on NRCON detects temperature more than 100°C.	Replace NRCON.

3.3.56 Error group 56: Interrupted exposure

Code	Reason	Action
56	User has interrupted exposure. User has released EXP button of the console before termination of exposure.	Check if button has contact fault.

3.3.57 Error group 57: NRCON SG fault

Code	Reason	Action
57	There is no output impulse on kV controller U27 on board NRCON in 10 ms (radiography) or in 1 s (fluoroscopy) after starting exposure.	Replace NRCON.

3.3.58 Error group 58: Capacitor overvoltage

Code	Reason	Action
58	Overvoltage on capacitor bank detected by NRCON. Voltage on capacitor bank is above about 650V.	Check whether mains input voltage is high. Check whether jumpers JP7, JP8 on board HFIIB are closed. See chapter 3.3.33.

3.3.59 Error group 59: Invalid AEC termination

Code	Reason	Action
59	AEC stop signal received from board NRAEC when AEC was not selected.	Check if there is noise in the system (weak protective earth, etc.) Replace NRAEC. Replace NRCON.

3.3.60 Error group 60: Pulsed fluoro not supported

Code	*Reason*	*Action*
60	Pulsed fluoroscopy is configured to device on generator without pulsed fluoroscopy option.	Remove pulsed fluoroscopy selection from device configuration (see chapter 4.5.5 of document *R-3241 Generator Setup*).

3.3.61 Error group 61: Device config. error (AEC)

Code	*Reason*	*Action*
61	AEC is configured to a technique button on a generator without AEC option.	Remove AEC from device configuration (see chapter 4.5.2 of document *R-3241 Generator Setup*

3.3.62 Error group 62: NRCON SG freq unstable

Code	*Reason*	*Action*
62	Frequency of kV controller U27 on board NRCON is not stable or differs from configuration value.	Check parameter with service program: generator configuration / low level / main inverter PWM parameters / frequency. If it is not 50 kHz, please contact us. If frequency parameter is OK, then replace NRCON.

3.3.63 Error group 63: Output mA high

Code	*Reason*	*Action*
63	Output mA on tube is higher than: • generator maximum at radiography • 20 mA at fluoroscopy • 150 mA at pulse fluoroscopy • 30 mA at tube conditioning	Make tube calibration (see chapter 3.3 of document *R-3241 Generator setup*).

3.3.64 Error group 64: Device config. error (fluoro)

Code	*Reason*	*Action*
64	Fluoroscopy is configured to a technique button in a generator without fluoro option.	Remove fluoro selection from device configuration (see chapter 4.5.2 of document *R-3241 Generator Setup*).

3.3.65 Error group 65: NRCON I2C error

Code	*Reason*	*Action*
65	Exposure log writing has failed on E2PROM of board NRCON.	Replace NRCON.

3.3.66 Error group 66: mAs limit exceeded

Code	*Reason*	*Action*
66	Output mAs has reached generator maximum value.	Make tube calibration (see chapter 3.3 of document *R-3241 Generator setup*).

3.3.67 Error group 67: kW limit exceeded

Code	*Reason*	*Action*
67	Output kW has reached generator maximum value.	Make tube calibration (see chapter 3.3 of document *R-3241 Generator setup*).

3.3.68 Error group 68: kWs/min limit exceeded

Code	*Reason*	*Action*
68	Output kWs/min has reached generator maximum value.	Check if there were too frequent exposures. Make tube calibration (see chapter 3.3 of document *R-3241 Generator setup*).

3.3.69 Error group 69: Device config. error (tube)

Code	*Reason*	*Action*
69	Tube 2 is configured to a technique button in a generator without 2nd tube option.	Set tube selection correctly in device configuration (see chapter 4.5.2 of document *R-3241 Generator Setup*).

3.3.70 Error group 70: AEC dose low

Code	*Reason*	*Action*
70	Voltage from AEC chamber has not reached 12.5 % of its end value when time (exposure time / 8 + 5 ms) has reached.	Increase exposure mAs. Increase exposure kV. Check voltage from AEC chamber. Check whether NRAEC board selects chambers correctly (after pushing preparation). If there is no change, replace NRAEC. Try to make AEC calibration. Check signal *AEC01*. If it is not present when chamber signal is OK, replace NRAEC.

3.3.71 Error group 71: Exposure switch inhibited

Code	*Reason*	*Action*
71 ; 0	Exposure switch is pushed on console when exposure switch of table is active.	Use another exposure switch. You can order exposure switch to console or device by service program (see chapter 4.5.2 of document *R-3241*

Code	Reason	Action
		Generator Setup).
71 ; 1	Exposure switch is pushed on table when exposure switch of console is active.	Like 71 ; 0.

3.3.72 Error group 72: Communication error

Code	Reason	Action
72	Communication problem at configuration data request.	Probably software problem, please contact us.

3.3.73 Error group 73: Config write error

Code	Reason	Action
73	Writing of database on NRRAD E2PROM from NRCON has failed.	Communication or software problem. Please contact us.

3.3.74 Error group 74: Console comm. error

Code	Reason	Action
74	Communication problem between NRCON and NRSRC (CAN2).	Communication or software problem. Please contact us.

3.3.75 Error group 75: Board database error

Code	Reason	Action
75	NRCON detects more boards in generator than it is possible.	Communication or software problem. Please contact us.

3.3.76 Error group 76: Preparation too long

Code	Reason	Action
76	Too long preparation. 10 seconds has elapsed after pushing preparation button on console without pressing exposure button.	Ask user not to use so high preparation. Check exposure button.

3.3.77 Error group 77: NRLHS missing

Code	Reason	Action
77	NRLHS board is not present after power on but it is configured.	Check generator configuration (see chapter 4.9.1 of document *R-3241 Generator setup*). Check CAN bus according to chapter

Code	*Reason*	*Action*
		3.1.2 / 2. If CAN bus is proved to be OK, replace NRLHS board.

3.3.78 Error group 78: NRAEC missing

Code	*Reason*	*Action*
78	NRAEC board is not present after power on but it is configured.	Check generator configuration (see chapter 4.9.1 of document *R-3241 Generator setup*). Check AEC control signals on J3 of NRCON with oscilloscope after power on. If you find request after power on on pins 2 and 3, and after it pin 6 does not change from H to L, replace NRAEC board, otherwise replace NRCON.

3.3.79 Error group 79: NRFIF missing

Code	*Reason*	*Action*
79	NRFIF board is not present after power on but it is configured.	Check generator configuration (see chapter 4.9.1 of document *R-3241 Generator setup*). Check CAN bus according to chapter 3.1.2 / 2. If CAN bus is proved to be OK, replace NRFIF board.

3.3.80 Error group 80: No high speed starter

Code	*Reason*	*Action*
80	High speed is selected but not high speed starter is configured.	Communication or software problem. Please contact us.

3.3.81 Error group 81: Device config error

Code	*Reason*	*Action*
81	No tube is configured to technique buttons.	Enable at least one technique button (see chapter 4.5.2 of document *R-3241 Generator setup*).

3.3.82 Error group 82: kV limit violation

Code	*Reason*	*Action*
82	Generator kV limit is higher in generator configuration than the absolute limit of the generator.	Check generator kV limit (see chapter 4.9.1 of document *R-3241 Generator setup*). Absolute limit is hard-wired to NRCON, you cannot modify it.

3.3.83 Error group 83: mA limit violation

Code	*Reason*	*Action*
83	Generator mA limit is higher in generator configuration than the absolute limit of the generator.	Check generator mA limit (see chapter 4.9.1 of document *R-3241 Generator setup*). Absolute limit is hard-wired to NRCON, you cannot modify it.

3.3.84 Error group 84: kW limit violation

Code	*Reason*	*Action*
84	Generator kW limit is higher in generator configuration than the absolute limit of the generator.	Check generator kW limit (see chapter 4.9.1 of document *R-3241 Generator setup*). Absolute limit is hard-wired to NRCON, you cannot modify it.

3.3.85 Error group 85: Fluoro violation

Code	*Reason*	*Action*
85	Fluoro option is selected in a radiographic generator configuration.	Check generator configuration (see chapter 4.9.1 of document *R-3241 Generator setup*). Fluoro support is hard-wired to NRCON, you cannot modify it.

3.3.86 Error group 86: mAs limit violation

Code	*Reason*	*Action*
86	Configuration data error on board NRCON.	Replace NRCON.

3.3.87 Error group 87: kWs/min limit violation

Code	*Reason*	*Action*
87	Configuration data error on board NRCON.	Replace NRCON.

3.3.88 Error group 88: Communication error

Code	*Reason*	*Action*
88	Communication or software problem during configuration data writing.	Please contact us.

3.3.89 Error group 89: No tube configured

Code	*Reason*	*Action*
89	In tube configuration no tube is enabled.	Select a tube insert and housing parameter set and enable tube (see chapter 4.2 of document *R-3241 Generator setup*).

3.3.90 Error group 90: Device config error

Code	*Reason*	*Action*
90	Tube 1 is selected for one of technique buttons in device configuration, but tube is not enabled in tube configuration.	Check device and tube configurations (see chapters 4.2 and 4.5.2 of document *R-3241 Generator setup*).

3.3.91 Error group 91: Device config error

Code	*Reason*	*Action*
91	Tube 2 is selected for one of technique buttons in device configuration, but tube is not enabled in tube configuration.	Check device and tube configurations (see chapters 4.2 and 4.5.2 of document *R-3241 Generator setup*).

3.3.92 Error group 92: Tube calibration error

Code	*Reason*	*Action*
92	Calculated filament current is out of range, probably because of wrong tube calibration data.	Make tube calibration (see chapter 3.3 of document *R-3241 Generator setup*)

3.3.93 Error group 93: Insert config error

Code	*Reason*	*Action*
93	No load is possible for selected tube, because tube insert settings or generator limits are faulty.	Check tube insert settings and generator limits (see chapters 4.3.3 and 4.9.1 of document *R-3241 Generator setup*)

3.3.94 Error group 94: AEC not calibrated

Code	*Reason*	*Action*
94	AEC calibration data is missing.	Make AEC calibration.

3.3.95 Error group 95: NRRAD communication error

Code	*Reason*	*Action*
95	CAN communication error between NRCON and NRRAD at standby filament. Generator is turned off.	Communication or software problem. Please contact us.

3.3.96 Error group 96: Fluoro hold timeout

Code	*Reason*	*Action*
96	CAN communication error between NRCON and NRFIF.	Communication or software problem. Please contact us.

3.3.97 Error group 97: Fluoro comm. error

Code	*Reason*	*Action*
97	CAN communication error between NRCON and NRFIF during fluoro preparation.	Communication or software problem. Please contact us.

3.3.98 Error group 98: Remote comm. error

Code	*Reason*	*Action*
98	CAN communication error between NRCON and fluoro remote controller.	Communication or software problem. Please contact us.

3.3.99 Error group 99: Fluoro comm. error

Code	*Reason*	*Action*
99	CAN communication error between NRCON and NRFIF during radiographic exposure.	Communication or software problem. Please contact us.

3.3.100 Error group 100: NRCON FPGA fault

Code	*Reason*	*Action*
100	Software download to FPGA U11 on board NRCON has failed.	Replace board NRCON.

3.3.101 Error group 101: NRCON SN fault

Code	*Reason*	*Action*
101	Communication problem on NRCON board.	Replace board NRCON.

3.3.102 Error group 102: Pulsed fluoro not supported

Code	*Reason*	*Action*
102	Pulsed fluoroscopy is configured on generator without pulsed fluoroscopy option.	Remove pulsed fluoroscopy selection from generator configuration (see chapter 4.9.1 of document *R-3241 Generator Setup*).

3.3.103 Error group 103: NRCON init error

Code	*Reason*	*Action*
103	Data is missing from E2PROMs of board NRCON. Data write failed.	Replace board NRCON.

3.3.104 Error group 104: NRCON I2C error

Code	*Reason*	*Action*
104	I2C communication failure on board NRCON at startup.	Replace board NRCON.

3.3.105 Error group 105: Console comm. error

Code	*Reason*	*Action*
105	CAN communication error between NRCON and console during preparation.	Communication or software problem. Please contact us.

3.3.106 Error group 106: Tomo not selected

Code	*Reason*	*Action*
106	Tomographic mode is not selected on tomographic table when tomographic technique is selected on console.	Turn on tomo mode on tomographic table. Apply a short circuit to pins J6/5-6 of board NRRAD. If error still exists, replace NRRAD.

3.3.107 Error group 107: NRRAD communication error

Code	*Reason*	*Action*
107	CAN communication error between NRCON and NRRAD during bucky start. Generator is turned off.	Communication or software problem. Please contact us.

3.3.108 Error group 108: NRRAD communication error

Code	*Reason*	*Action*
108	CAN communication error between	Communication or software problem.

Code	Reason	Action
	NRCON and NRRAD. Generator is turned off.	Please contact us.

3.3.109 Error group 109: NRRAD communication error

Code	Reason	Action
109	CAN communication error between NRCON and NRRAD. Generator is turned off.	Communication or software problem. Please contact us.

3.3.110 Error group 110: NRRAD communication error

Code	Reason	Action
110	CAN communication error between NRCON and NRRAD. Generator is turned off.	Communication or software problem. Please contact us.

3.3.111 Error group 111: NRRAD communication error

Code	Reason	Action
111	CAN communication error between NRCON and NRRAD during preparation. Generator is turned off.	Communication or software problem. Please contact us.

3.3.112 Error group 112: NRRAD communication error

Code	Reason	Action
112	CAN communication error between NRCON and NRRAD during preparation. Generator is turned off.	Communication or software problem. Please contact us.

3.3.113 Error group 113: NRRAD communication error

Code	Reason	Action
113	CAN communication error between NRCON and NRRAD during NRRAD E2PROM read. Generator is turned off.	Communication or software problem. Please contact us.

3.3.114 Error group 114: NRRAD fault

Code	Reason	Action
114	CAN communication error between NRCON and NRRAD during charging. Generator is turned off. NRRAD is likely not to work.	See chapter 3.1.2 / 2.

3.3.115 Error group 115: NRRAD communication error

Code	*Reason*	*Action*
115	CAN communication error between NRCON and NRRAD after charging. Generator is turned off.	Communication or software problem. Please contact us.

3.3.116 Error group 116: NRRAD communication error

Code	*Reason*	*Action*
116	CAN communication error between NRCON and NRRAD at error. Generator is turned off.	Communication or software problem. Please contact us.

3.3.117 Error group 117: Console communication error

Code	*Reason*	*Action*
117	CAN communication error between NRCON and console.	Communication or software problem. Please contact us.

3.3.118 Error group 118: Console communication error

Code	*Reason*	*Action*
118	CAN communication error between NRCON and console at error.	Communication or software problem. Please contact us.

3.3.119 Error group 119: Please release exp. button

Code	*Reason*	*Action*
119	Exposure button is not released after exposure for about 10 seconds.	Release exposure button.

3.3.120 Error group 120: NRCON software error

Code	*Reason*	*Action*
120	Software error on board NRCON.	Please contact us.

3.3.121 Error group 121: AEC level error

Code	*Reason*	*Action*
121	The calculated level for AEC turn off is too high or too low.	Make AEC calibration (see chapter 3.5 of document *R-3241 Generator Setup*).

3.3.122 Error group 122: AEC backup time termination

Code	*Reason*	*Action*
122	Exposure was not terminated during exposure time by AEC.	Check exposure parameters. Check AEC calibration. Replace NRAEC board. Replace NRCON.

3.3.123 Error group 123: Spot parameter overload

Code	*Reason*	*Action*
123	Spot exposure parameters are out of tube load limits	Check spot multiplying parameters with service program (see chapter 4.5.5 of document *R-3241 Generator Setup*).

3.3.124 Error group 124: NRFIF communication error

Code	*Reason*	*Action*
124	CAN communication error between NRCON and NRFIF.	Communication or software problem. Please contact us.

3.3.125 Error group 125: NRFIF communication error

Code	*Reason*	*Action*
125	CAN communication error between NRCON and console.	Communication or software problem. Please contact us.

3.3.126 Error group 126: Tube configuration error (HS)

Code	*Reason*	*Action*
126	A high speed only tube connected to low speed starter.	Repair tube configuration or order tube to high speed starter (see chapters 4.3.1 and 4.9.1 of document *R-3241 Generator Setup*).

3.3.127 Error group 127: Tube not configured

Code	*Reason*	*Action*
127	A not used tube is ordered to a technique button.	Enable tube in the main window of the service program, or delete disabled tube from device configuration (see chapters 4.2 and 4.5.2 of document *R-3241 Generator Setup*).

3.3.128 Error group 128: NRCON illegal E2PROM write

Code	*Reason*	*Action*
128	Illegal write to a special area of E2PROM on board NRCON.	Communication or software problem. Please contact us.

3.3.129 Error group 129: Device config error (fluoro)

Code	*Reason*	*Action*
129	Fluoroscopy is not ordered for technique button.	Select fluoroscopy for one of technique buttons (see chapter 4.5.2 of document *R-3241 Generator Setup*).

3.3.130 Error group 130: NRCON illegal E2PROM write

Code	*Reason*	*Action*
130	E2PROM write to an address out of memory range on board NRCON.	Communication or software problem. Please contact us.

3.3.131 Error group 131: NRFIF communication error

Code	*Reason*	*Action*
131	CAN communication error between NRCON and NRFIF.	Communication or software problem. Please contact us.

3.3.132 Error group 132: NRCON illegal E2PROM write

Code	*Reason*	*Action*
132	Illegal write to a special area of E2PROM on board NRCON.	Communication or software problem. Please contact us.

3.3.133 Error group 133: AEC not configured

Code	*Reason*	*Action*
133	AEC calibration: there is no device where AEC is configured	Set AEC for devices (see chapter 4.5.2 of document *R-3241 Generator setup*).

3.3.134 Error group 134: kWs limit violation

Code	*Reason*	*Action*
134	Configuration data error on board NRCON.	Replace NRCON.

3.3.135 Error group 135: APR not received at Trixell calibration

Code	*Reason*	*Action*
135	Communication or software problem on Trixell controller PC or generator.	Please contact us.

3.3.136 Error group 136: Device config error (fluoro)

Code	*Reason*	*Action*
136	Both tube 1 and 2 are configured for fluoroscopy. Generator supports only one fluoroscopic device.	Set device configuration properly (see chapter 4.5.2 of document *R-3241 Generator setup*).

3.3.137 Error group 137: Digital imager not ready

Code	*Reason*	*Action*
137	Device button is configured to wait for a ready signal from an external PC through serial port of the console. Preparation requested if external system (e.g. PC of digital imager) is not ready for X-ray.	Check communication between console and PC. Check device configuration (see chapter 4.5.2 of document *R-3241 Generator setup*).

3.3.138 Error group 138: Digital imager not ready

Code	*Reason*	*Action*
138	Device button is configured to wait for a ready signal from an external PC through serial port of the console. External system (e.g. PC of digital imager) is not ready for X-ray under preparation, after 5 seconds.	Check communication between console and PC. Check device configuration (see chapter 4.5.2 of document *R-3241 Generator setup*).

3.3.139 Error group 139: Bucky not ready

Code	*Reason*	*Action*
139	Bucky ready signal has disappeared during exposure.	Check bucky ready signal on board NRRAD.

3.3.140 Error group 140: Device config. error (tomo)

Code	*Reason*	*Action*
140	Tomographic exposure is configured to console, but no bucky is configured for it.	In device configuration set "exposure from" to "device" (in case of remote controlled table), or select a bucky for tomo (in case of bucky table). See chapter 4.5.2 of document *R-3241 Generator setup*.

4. ORDERING AND REPLACING PARTS

4.1 Ordering parts

You can order a component or spare part in the following way:

1. Find part number of requested component in the spare part list (in appendix of this document).

2. If you order a board with microcontroller, please also read software version number from the sticker on the microcontroller.

3. Fill component order form *R-3487* in the appendix with this data. You can also fill serial numbers (it is also a sticker on the board). We kindly request you to fill as many data in the form as possible in order to receive the spare part needed.

4. If you order NRCON board, please also send us the following data:
   - generator maximum kV
   - generator maximum kW
   - generator load mode: radiography only or fluoroscopy

   These settings are hard-wired to NRCON board.
   Price of NRCON also depends on these settings.

5. Send component order form to us:
   by fax: 36-1-460 9222
   by e-mail: xrayservice@innomed.hu
   If you have any technical question, you can also contact us on this e-mail address.

4.2 Cautions for replacing parts

The following precautions should be observed before replacing the following components:

4.2.1 Replacing NRRAD

In E2PROM U21 the following data is stored:
- tube insert parameters
- tube housing parameters
- device configuration (technique)
- generator configuration
- all calibration data (tube, AEC, ...)
- error log

If you replace NRRAD, remove E2PROM U21 from its socket and put it to the new board.

Copy all jumper and DIP switch settings to the new board. Be careful with jumpers JP1-JP3: for 230VAC bucky interface voltage they should be open, for 24VDC bucky interface voltage they should be closed.

After replacing NRRAD difference in filament current can occur. Test mA accuracy with a low kV, low mA exposure on large focal spot. In case of big difference turn slightly filament calibration potentiometer NRRAD/P1, or make a new tube calibration.

4.2.2 Replacing NRCON

The following data is hard-wired on NRCON board:
- generator maximum kV
- generator maximum kW
- generator load mode: radiography only or fluoroscopy

These parameters cannot be modified, when you order board, you need to send them to us.

The following data is stored in E2PROMs of NRCON:
- exposure counters
- exposure logs

These parameters will be lost after replacing NRCON board. You can read and save them with service program before replacing NRCON.

4.2.3 Replacing console or fluoro remote controller (NRSRC, NRSFC)

The following data is stored in E2PROMs of NRSRC and NRSFC:
- language settings (character sets, texts)
- anatomical programs
- console settings (LCD contrast, buzzer volume, etc.)

These parameters will be lost after replacing board. You can read them and download them to new console with service program.

4.2.4 Replacing IGBTs

Replace IGBTs according to service instructions we send with ordered IGBTs.
In case of replacing IGBTs always replace the driver board HFIGB too.

4.2.5 Replacing high voltage tank

After replacing high voltage tank check mA accuracy with low kV, low mA test exposures. Make tube calibration again if it is necessary.

4.2.6 Replacing NRFIL

After replacing NRFIL difference in filament current can occur. Test mA accuracy with a low kV, low mA exposure on small focal spot. In case of big difference turn slightly filament calibration potentiometer P1 on NRFIL_CTR (daughter board of NRFIL), or make a new tube calibration.

5. SOFTWARE UPGRADE

5.1 Connecting and setting boards for software upgrade

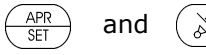
5.1.1 Connecting console and fluoro remote controller

1. Connect console and fluoro remote controller to PC according to chapters 4.1.1 or 4.1.2 of document *R-3241 Generator Setup* with software upgrade cable R-4491-3.

   You can order software upgrade cable from Innomed, or you can make it from accessory cable R-3255-3 with disassembling D-SUB 9 connector (PC side) and connecting yellow wire to pin 5 (GND).
2. Turn generator on. LCD display of console or fluoro remote controller is dark. Red LED LD10 on console or remote is on.
3. Download software from PC according to chapter 5.2.
4. Turn generator off.
5. Remove download cable.
6. In case of software upgrade on console or remote it is usually recommended to upgrade language file too. See chapter 4.6.4 of document *R-3241 Generator setup*.

5.1.2 Connecting NRMCU (NRRAD, NRFIF, NRLHS)

1. Connect connector NRMCU/J2 to PC with download cable (R-4492-3). You can order this cable from Innomed.

   Warning! GND of NRMCU is connected to protective earth of the generator. It is recommended to do software upgrade with a PC that is galvanically isolated from protective earth of the mains (e.g. notebook).
2. Set DIP switches of NRMCU/SW2 (PROG) on.
3. In case of software upgrade to NRRAD:
   - Remove connector from NRRAD/J6 (or if NRTUS is present, from NRTUS/J4 and NRTUS/J5)
   - Set jumper NRRAD/JP6 (DISABLE WD SHUTDOWN) on.
4. Turn on the generator while pushing and holding buttons 

and  of the console.
5. Download software with PC according to chapter 5.2.
6. Turn generator off. Remove jumper NRRAD/JP6. Set DIP switches NRMCU/SW2 off. Connect connector NRRAD/J6 (NRTUS/J4, NRTUS/J5) back.

5.1.3 Connecting NRCON

1. In case of NRCON107 (or above): connect connector NRCON/J6 to PC with console-PC interconnect cable (R-3255-3). This cable is shipped with all generators.

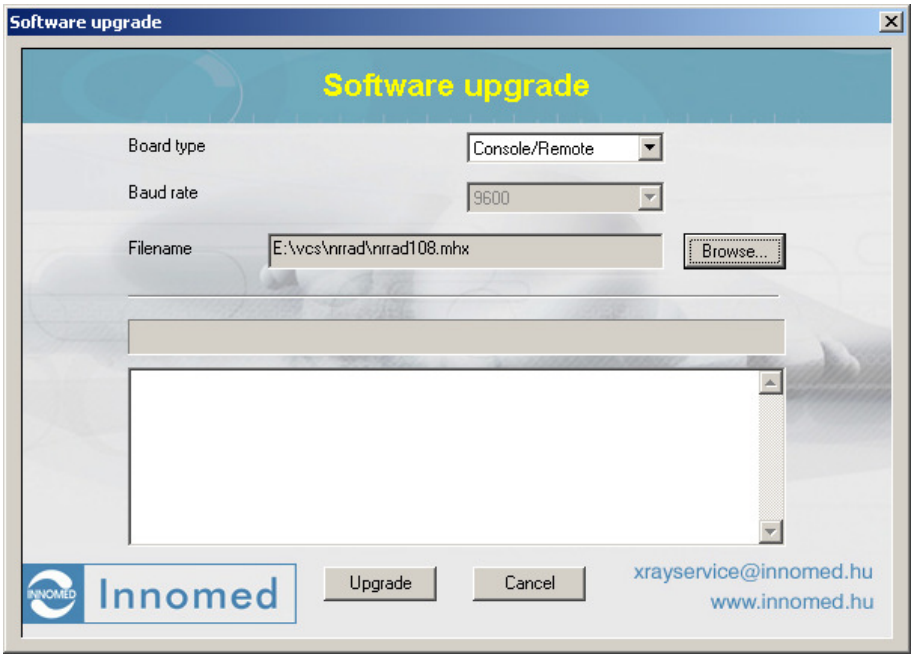
   In case of NRCON105 (or below): connect connector NRCON/J5 to PC with download cable (R-4492-3). You can order this cable from Innomed.

Warning! In case of NRCON107 (or above) GND of NRCON is connected to protective earth of the generator. It is recommended to do software upgrade with a PC that is galvanically isolated from protective earth of the mains (e.g. notebook).

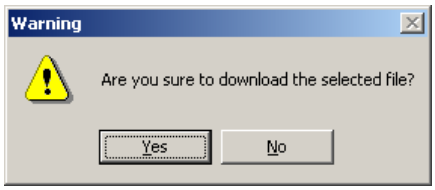
2. Set DIP switch NRCON/S2/1 (FLASH PROG) on.
3. Turn on the generator. Red LED LD12 on NRCON will show that board is in programming mode.
4. Download software with PC according to chapter 5.2.
5. Turn generator off. Set DIP switch NRCON/S2/1 off.

5.2 Downloading software with service program

1. Start service program *topxnr.exe.*
2. Select menu **Data transfer / Software upgrade...** :



3. Select board type ('Console/Remote' or 'NRMCU' or 'NRCON')
4. In case of NRCON set baud rate to 9600 for NRCON105 (or below) or to 38400 for NRCON107 (or above).
5. Select program file to download with **Browse...** button.
6. Click **Upgrade** button. A message box appears:



7. Select **Yes**. Software upgrade will proceed automatically. You can see, what is happening in the white window above buttons **Upgrade**, **Cancel**.
8. Exit software upgrade window with **Cancel** button.

APPENDIX

Spare part list

Component order form