

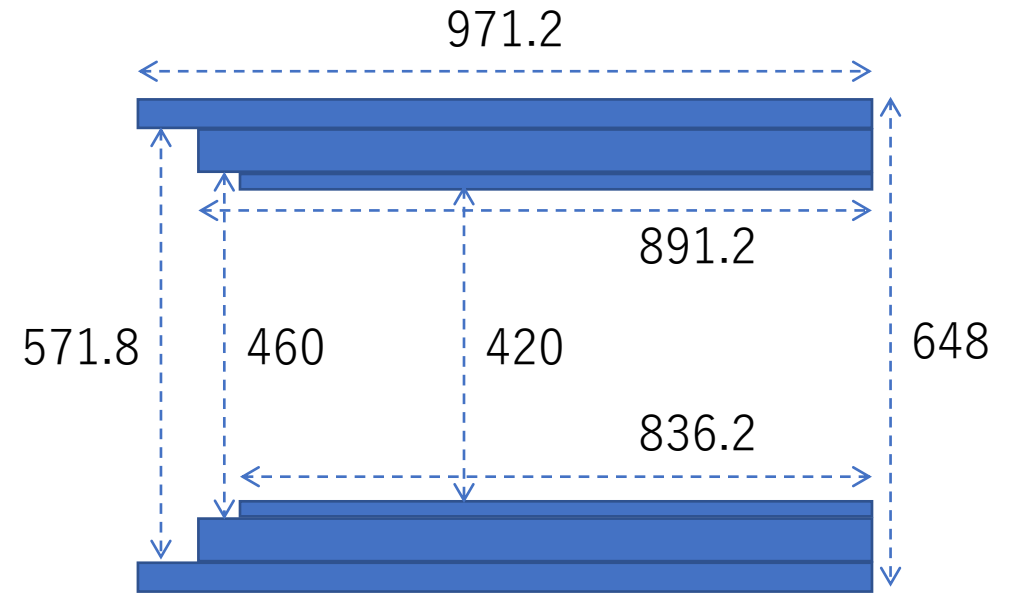
HRGC2

Stand Alone Test Results

KFMI

January 18 2023

Dimensions



Weight: ~380 kg

LCR Measurement

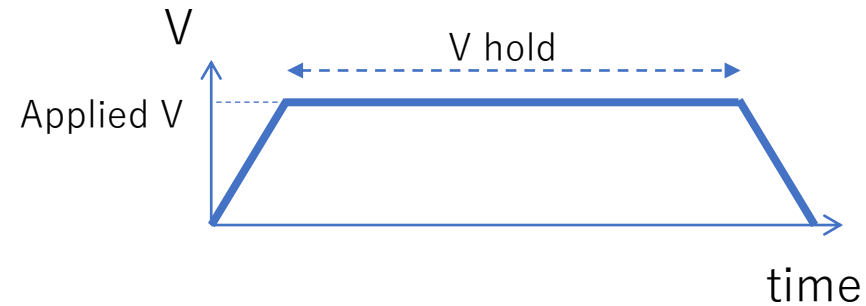
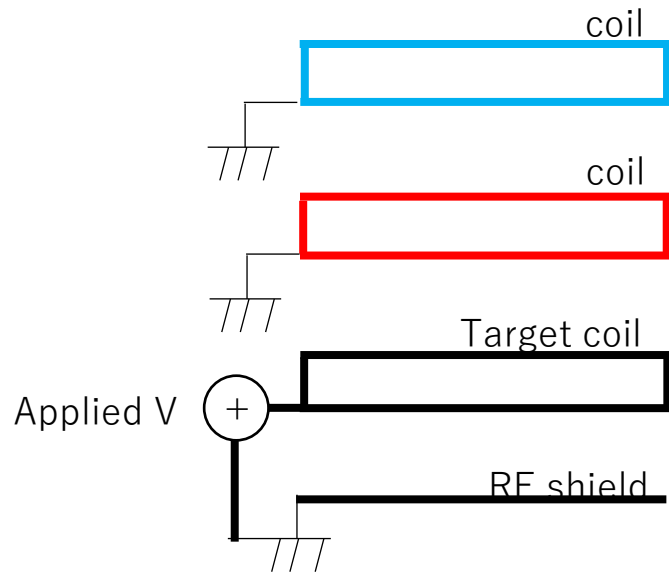
	X coil	Y coil	Z coil
R [mOhm]	87.4	95.4	120.4
L [uH]	263.7	291.2	427.6

R: $R_{dc} / 1.00$ [V]

L: $L_s / 1.00$ [V] / 1000 [Hz]

Mutual Inductance	X - Y	X - Z	Y - Z
M [uH]	3.7	-2.7	-1.1

Withstand Voltage Test



V rise: 10 sec
V hold: 60 sec
 V fall: 10 sec

	X coil	Y coil	Z coil
Applied V [V]	3600	3600	3600
R [Mohm]	$9.0 * 10^3$	$5.1 * 10^3$	$9.0 * 10^3$

All coils: ~ **10 Gohm @3600V**



No break down under 3600V = can be used for 2000V rated voltage

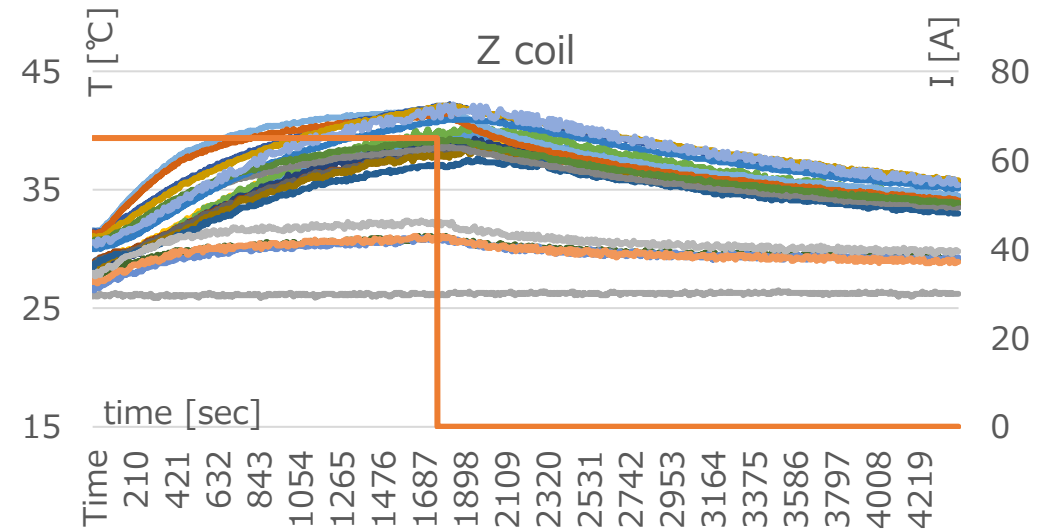
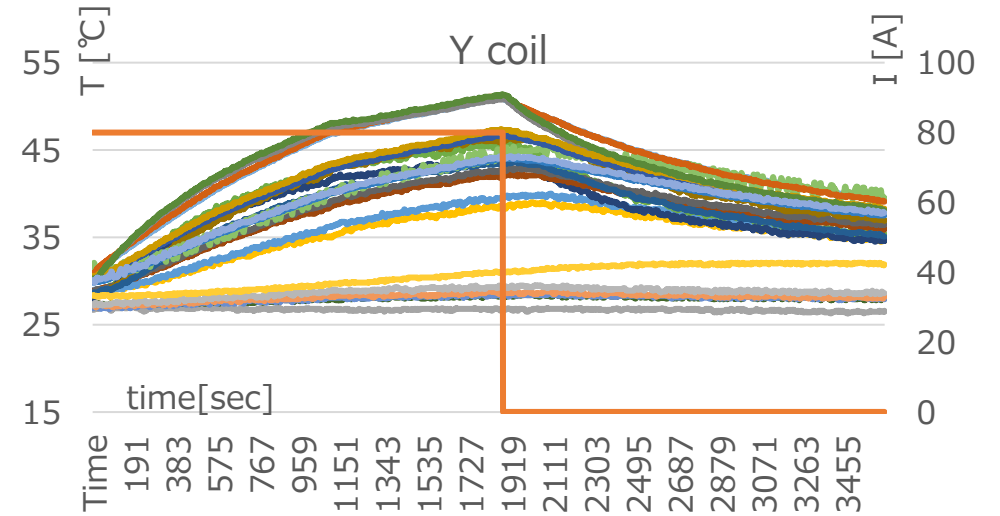
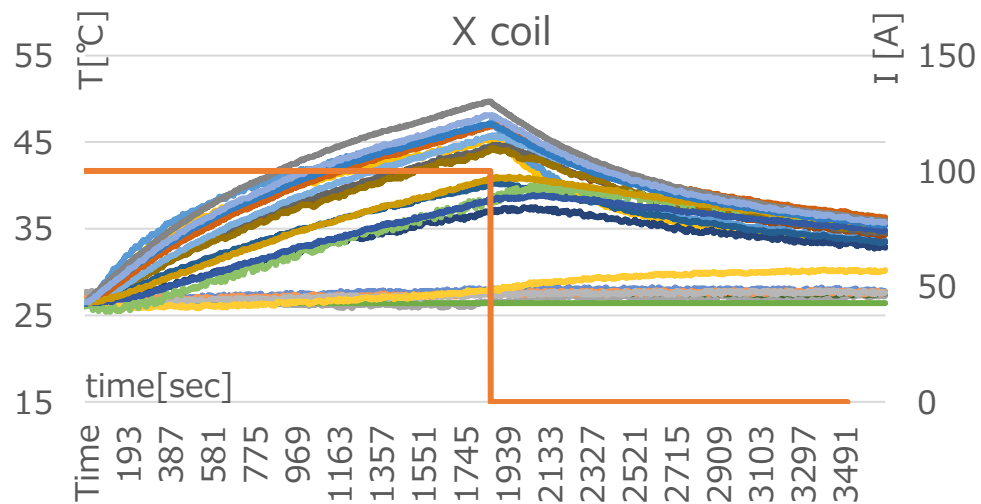
Thermal Test (w/o water cooling)

RT ~ 27 °C / Thermocouple / DC current

X coil: 100 A / ~30 min / max ~50 °C

Y coil: 80 A / ~30 min / max ~50 °C

Z coil: 65 A / ~30 min / max ~40 °C

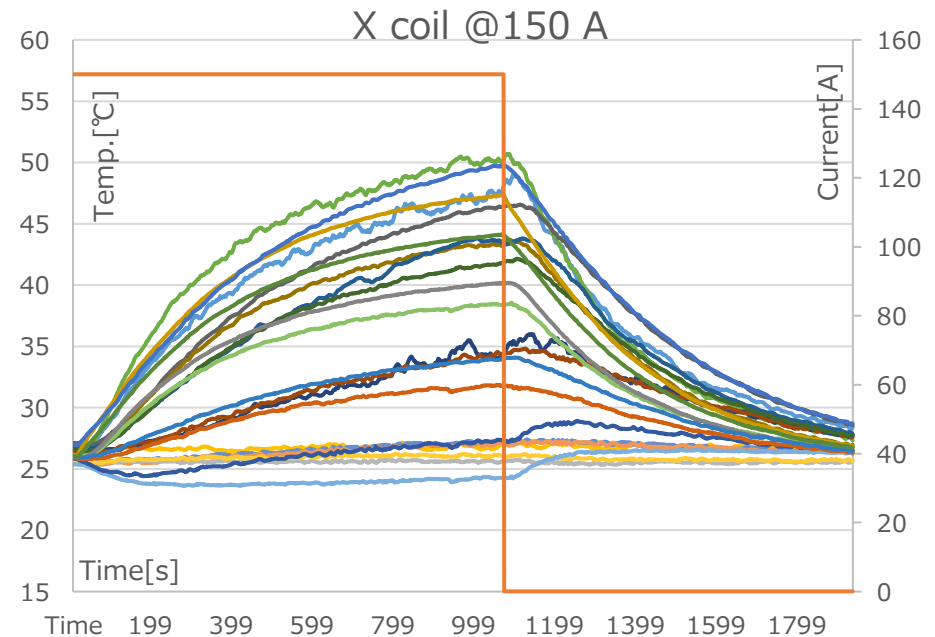
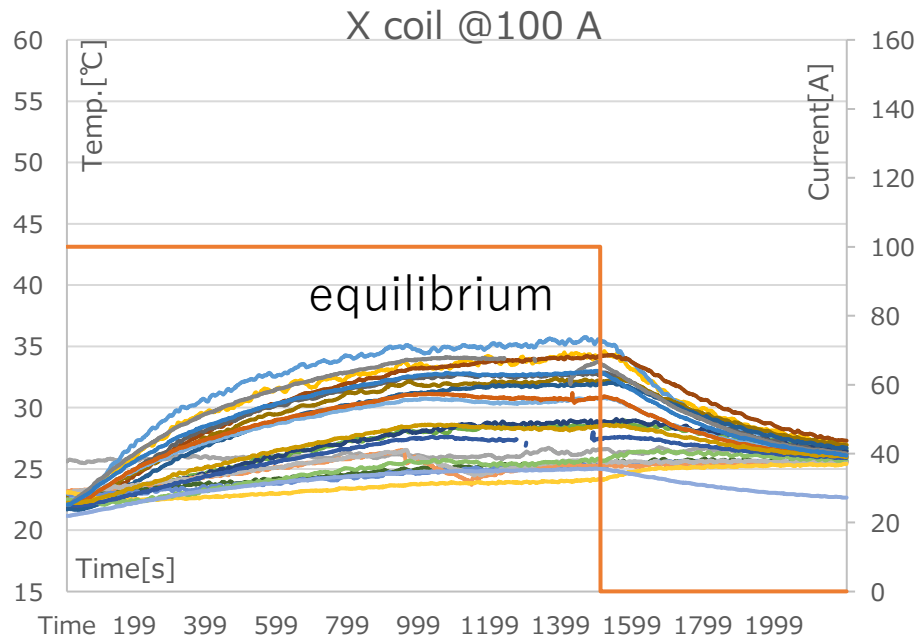


Thermal Test (w/ water cooling): X coil

RT ~ 27 °C / Thermocouple / DC current / Water: in, 0.175 MPa; out, 0 MPa

X coil: 100 A / ~25 min / max ~35 °C
Water in ~25.3 °C / out ~25.6 °C @~25min

X coil: 150 A / ~18 min / max ~50 °C
Water in ~25.5 °C / out ~26.1 °C @~18min

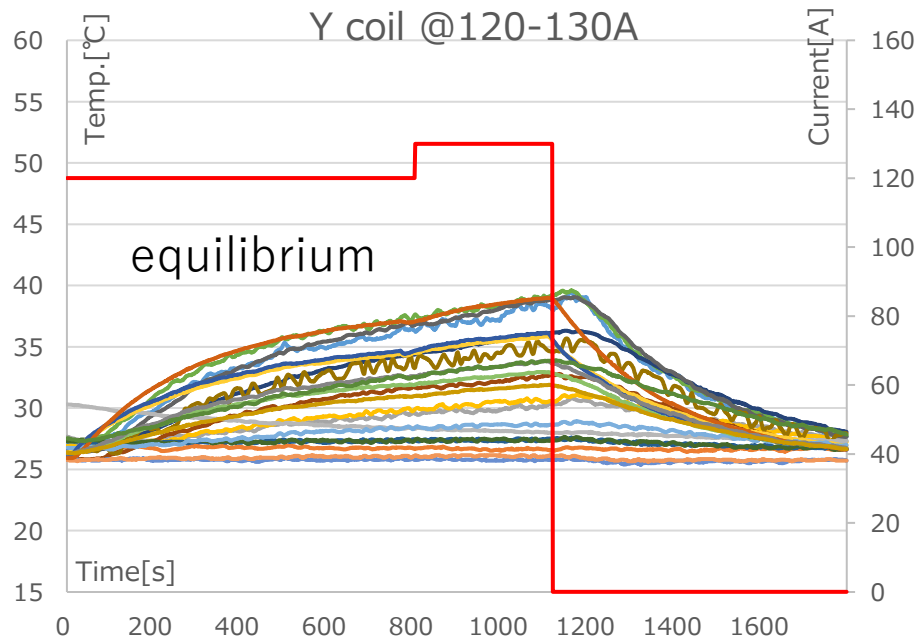


↔ **X coil w/o cooling: 100 A / ~30 min / max ~50 °C**

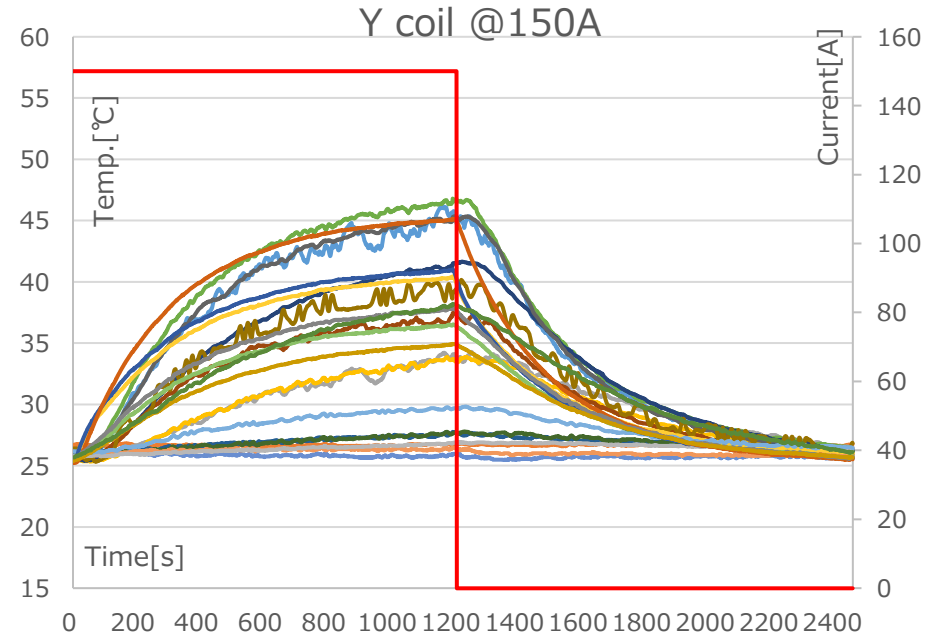
Thermal Test (w/ water cooling): Y coil

RT ~ 27 °C / Thermocouple / DC current / Water: in, 0.175 MPa; out, 0 MPa

Y coil: 120-130 A / ~18 min / max ~40 °C
Water in ~25.8 °C / out ~26.1 °C @~18min



Y coil: 150 A / ~20 min / max ~45 °C
Water in ~26.0 °C / out ~26.5 °C @~20min



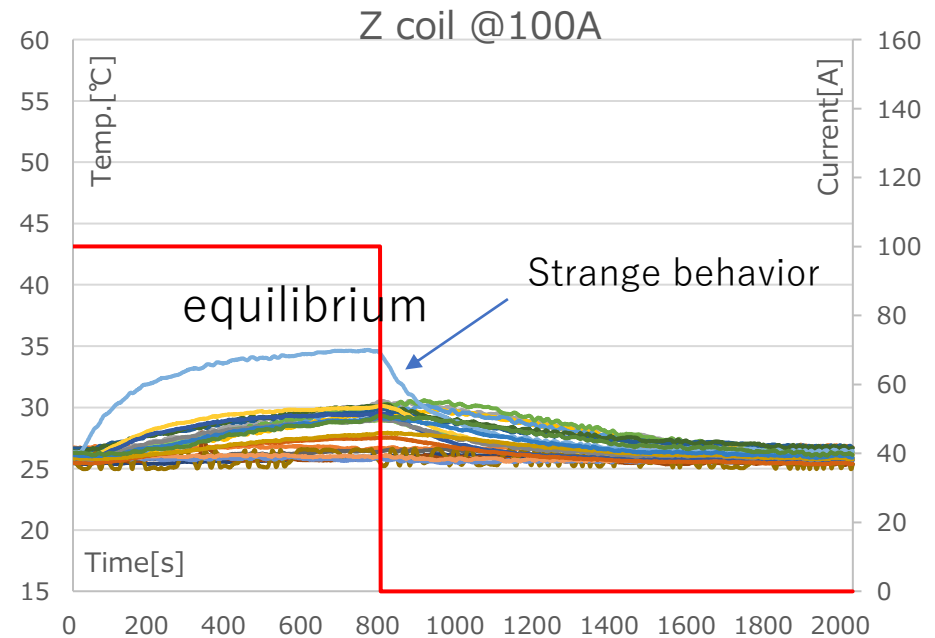
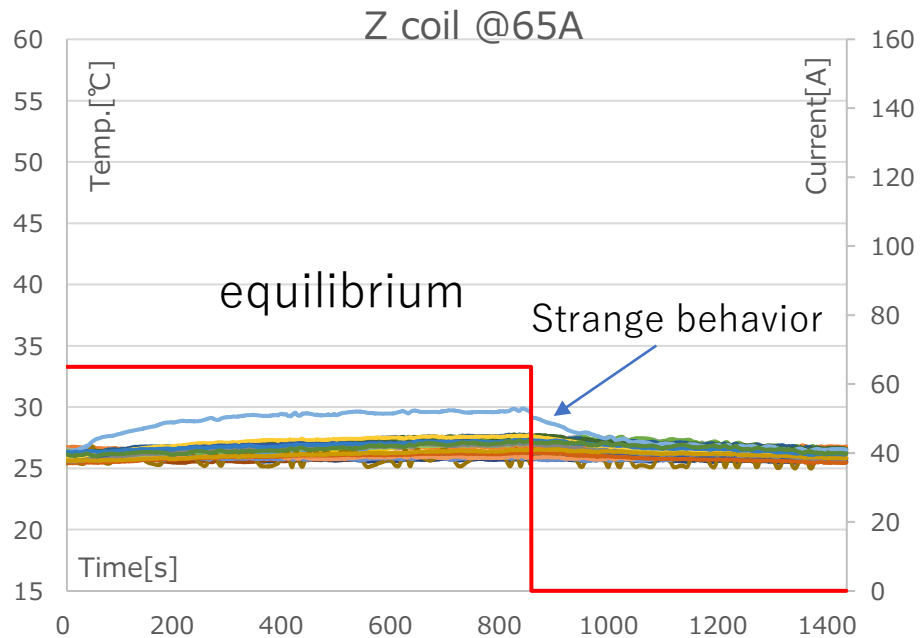
↔ **Y coil w/o cooling: 80 A / ~30 min / max ~50 °C**

Thermal Test (w/ water cooling): Z coil

RT ~ 27 °C / Thermocouple / DC current / Water: in, 0.175 MPa; out, 0 MPa

Z coil: 65 A / ~14 min / max ~30 °C
Water in ~25.9 °C / out ~26.0 °C @~14min

Z coil: 100 A / ~14 min / max ~35 °C
Water in ~25.7 °C / out ~26.0 °C @~14min

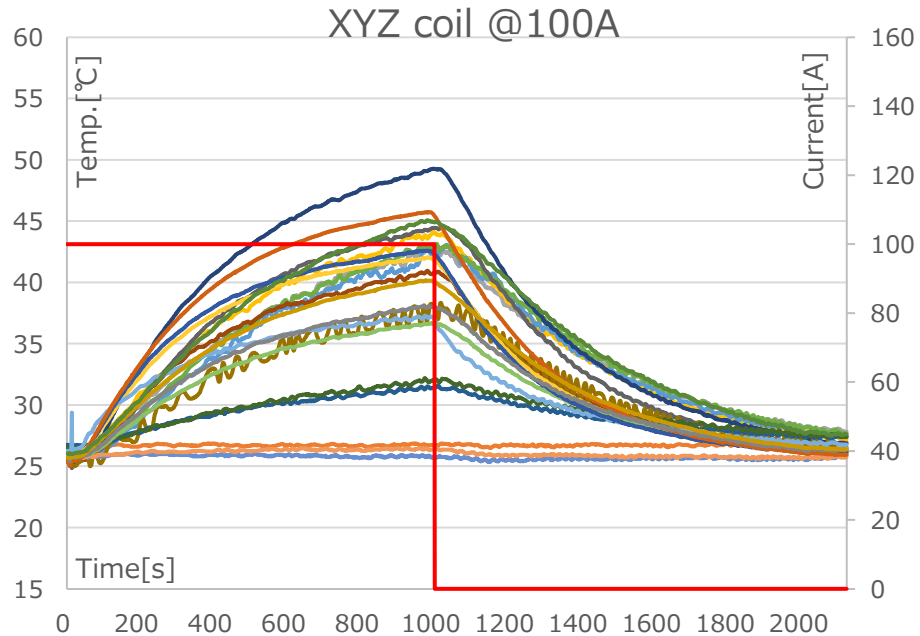


↔ **Z coil w/o cooling: 65 A / ~30 min / max ~40 °C**

Thermal Test (w/ water cooling): XYZ coil

RT ~ 27 °C / Thermocouple / DC current / Water: in, 0.175 MPa; out, 0 MPa
X, Y, Z coils in series

X-Y-Z coils: 100 A / ~17 min / max ~50 °C
Water in ~**25.7 °C** / out ~**26.4 °C** @~17min



Highest temperature
@inner surface

Thermal Test Summary

Water cooling: working properly

Maximum Temperature w/ water cooling < MaxT w/o water cooling

Equilibrium maximum temperature

X coil: 874 w (@DC100A) ~ 35 °C

Y coil: 1,374 w (@DC120A) ~ 37 °C

Z coil: 954 w (@DC100A) ~ 35 °C

Highest temperature @inner surface

Small temperature difference between the Water in and out

Zero pressure @ the Water out

Magnetic field measurement

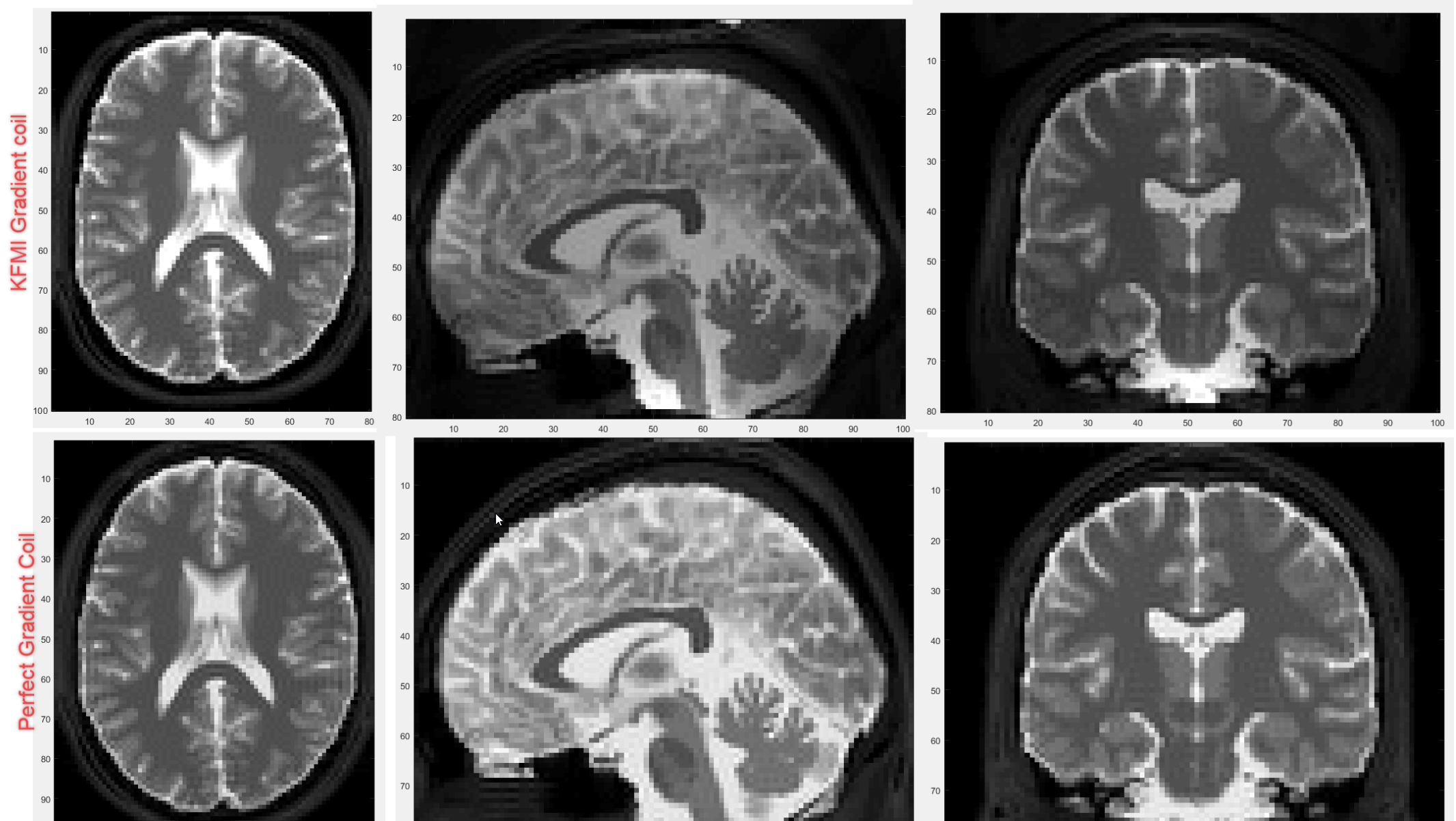
	X coil	Y coil	Z coil
Efficiency [μ T/m/A]	176	178	270
Gradient Field ($I_{\text{peak}}=850\text{A}$) [mT/m]	150	151	230
Maximum non-linearity @ 260mm DSV	16%	10%	10%

Estimated Slew Rate

X Coil {
Rated Voltage 2000V $\rightarrow L \cdot di/dt = 267.7[\mu\text{H}] \cdot 850[\text{A}] / \Delta T \rightarrow \Delta T = 112 \cdot 10^{-6}[\text{sec}]$
Slew Rate = $150[\text{mT/m}] / 112 \cdot 10^{-6}[\text{sec}]$
 \doteq **1300**[T/m/sec]

Z Coil {
Rated Voltage 2000V $\rightarrow L \cdot di/dt = 427.6[\mu\text{H}] \cdot 850[\text{A}] / \Delta T \rightarrow \Delta T = 182 \cdot 10^{-6}[\text{sec}]$
Slew Rate = $230[\text{mT/m}] / 182 \cdot 10^{-6}[\text{sec}]$
 \doteq **1200**[T/m/sec]

Simulated Brain Imaging under the KFMI Gradient coil conditions



Simulation : MRILab, GRADIENT-ECHO PSD_GRE3D