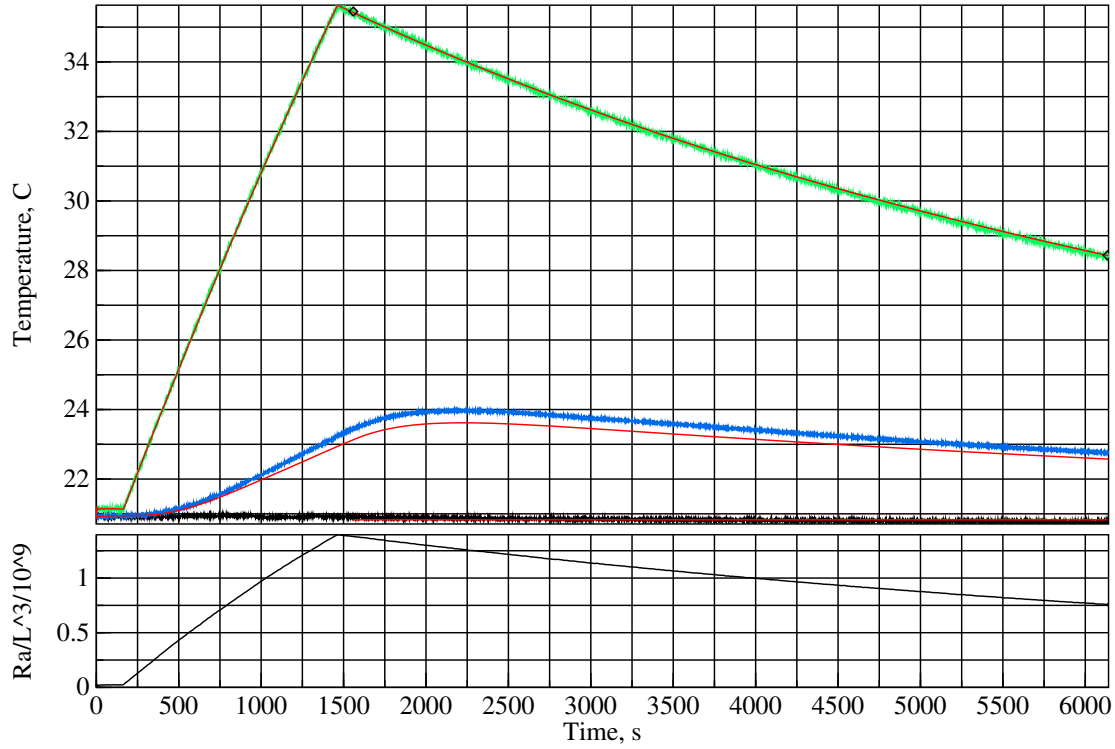


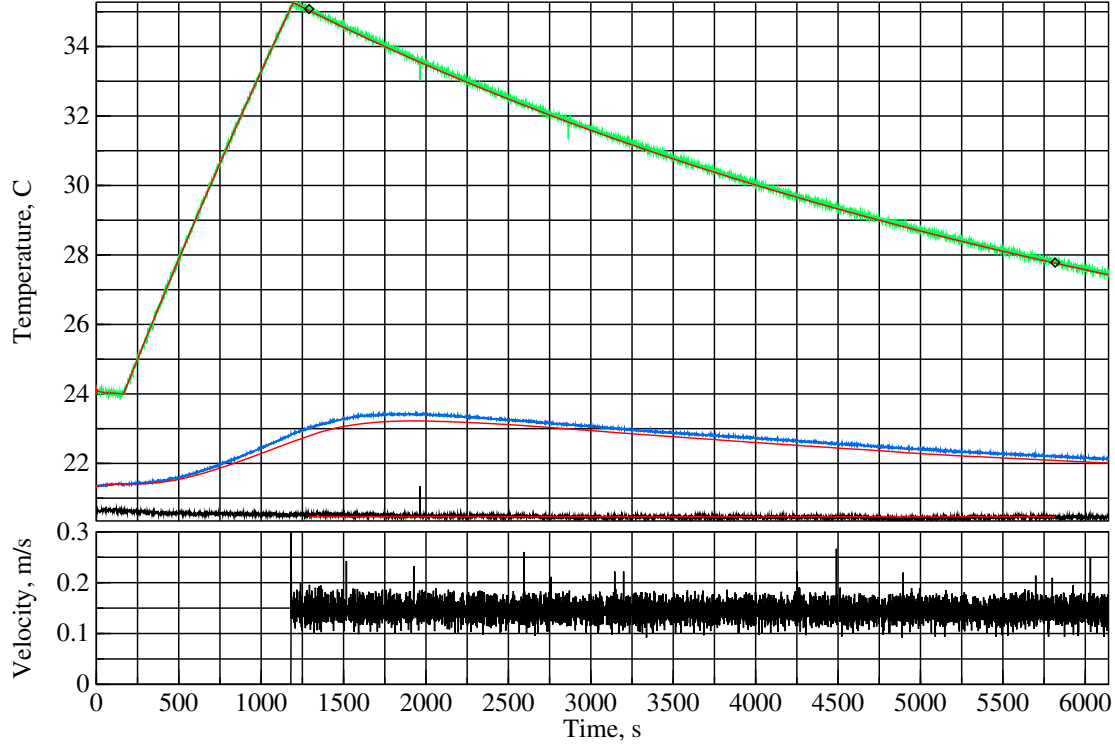
20160924T230208Z – mixed Convection – Roughness=3.00mm; T=20.8+10.6°C; +0.00°  
k=0.0257, Ra/L^3=1.035x10^9, h=3.59W/(K.m^2), U=0.334W/K, Nu=42.7, Pr=0.709



Estimated measurement uncertainties of natural convection at  $\theta = 0.0$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.6K	+22.1%/K	0.10K	2.21%	LM35C differential
$P$	101kPa	+0.0007%/Pa	1.5kPa	1.03%	MPXH6115A6U air pressure
$C_{pt}$	4.69kJ/K	+0.043%/(J/K)	47J/K	2.00%	plate thermal capacity
$C_V$	1.000	-14.2%	0.100	1.42%	vertical reuptake
$L_c$	0.305m	+605%/m	500um	0.30%	characteristic length
$D_{PIR}$	25.4mm	-515%/m	1.0mm	0.51%	insulation thickness
$D_g$	1.00mm	-522%/m	500um	0.26%	air gap
$L_m$	3.57mm	+1124%/m	500um	0.56%	side metal strip width
$k_{PIR}$	22.2 $\frac{mW}{K \cdot m}$	+0.498%/ $\frac{mW}{K \cdot m}$	1.1 $\frac{mW}{K \cdot m}$	0.55%	PIR thermal conductivity
$\epsilon_{XPS}$	0.515	+36.2%	0.010	0.36%	XPS emissivity
$\epsilon_{tp}$	0.890	+43.5%	0.015	0.65%	tape emissivity
$\Omega_{tp}$	0.540	+29.5%	0.020	0.59%	tape coverage
$\epsilon_{rs}$	0.040	+152%	0.010	1.52%	test-surface emissivity
$\epsilon_{wt}$	0.900	+71.2%	0.025	1.78%	wind-tunnel emissivity
				4.41%	combined bias uncertainty

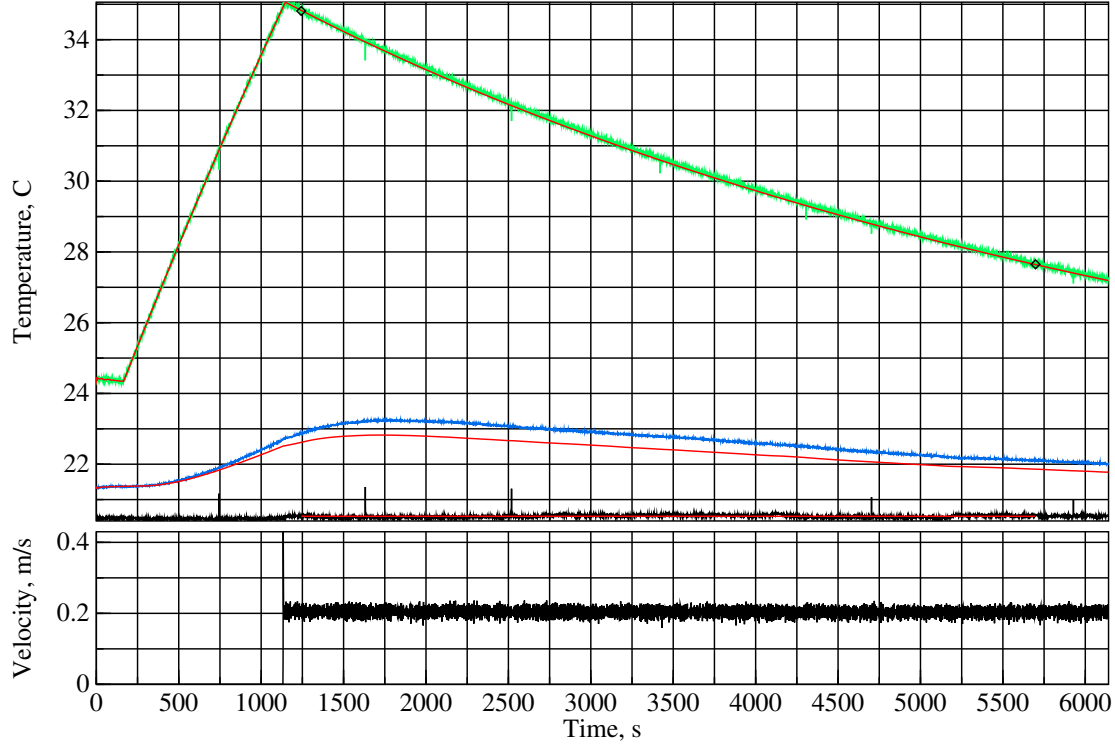
20160925T204755Z – mixed Convection – Roughness=3.00mm; T=20.5+10.5°C; +0.00°  
41±5.4r/min, V=0.15m/s, Re=2959, Ra/L^3=1.027x10^9, h=4.08W/(K.m^2), U=0.379W/K, Nu=48.5



Estimated measurement uncertainties, bi-level 3mm roughness at  $Re = 2959$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.5K	+20.9%/K	0.10K	2.09%	LM35C differential
$P$	101kPa	+0.0007%/Pa	1.5kPa	1.11%	MPXH6115A6U air pressure
$C_{pt}$	4.69kJ/K	+0.040%/(J/K)	47J/K	1.88%	plate thermal capacity
$\eta$	0.401	+37.1%	0.014	0.52%	anemometer calibration
$C_V$	1.000	−12.5%	0.100	1.25%	vertical reuptake
$L_c$	0.305m	+504%/m	500um	0.25%	characteristic length
$D_{PIR}$	25.4mm	−444%/m	1.0mm	0.44%	insulation thickness
$D_g$	1.00mm	−450%/m	500um	0.22%	air gap
$L_m$	3.57mm	+1093%/m	500um	0.55%	side metal strip width
$k_{PIR}$	22.2 $\frac{mW}{K \cdot m}$	+0.439%/ $\frac{mW}{K \cdot m}$	1.1 $\frac{mW}{K \cdot m}$	0.49%	PIR thermal conductivity
$\epsilon_{XPS}$	0.515	+31.5%	0.010	0.32%	XPS emissivity
$\epsilon_{tp}$	0.890	+37.9%	0.015	0.57%	tape emissivity
$\Omega_{tp}$	0.540	+25.7%	0.020	0.51%	tape coverage
$\epsilon_{rs}$	0.040	+133%	0.010	1.33%	test-surface emissivity
$\epsilon_{wt}$	0.900	+62.1%	0.025	1.55%	wind-tunnel emissivity
				4.10%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	41.0r/min	+0.362%/(r/min)	5.4r/min	1.95%	fan rotation rate
				5.66%	RSS combined uncertainty

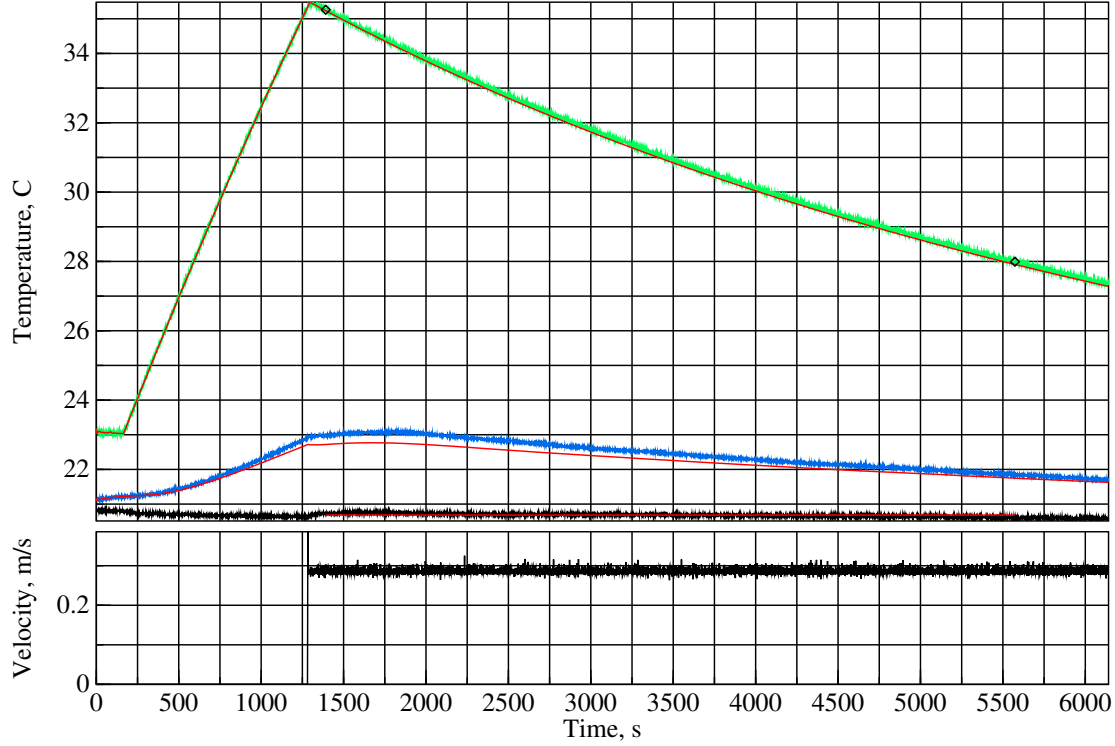
20160925T175225Z – mixed Convection – Roughness=3.00mm; T=20.5+10.3°C; +0.00°  
57±3.9r/min, V=0.20m/s, Re=4127, Ra/L^3=1.005x10^9, h=4.25W/(K.m^2), U=0.396W/K, Nu=50.5



Estimated measurement uncertainties, bi-level 3mm roughness at  $Re = 4127$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.3K	+20.7%/K	0.10K	2.07%	LM35C differential
$P$	101kPa	+0.0008%/Pa	1.5kPa	1.14%	MPXH6115A6U air pressure
$C_{pt}$	4.69kJ/K	+0.039%/(J/K)	47J/K	1.85%	plate thermal capacity
$\eta$	0.401	+55.6%	0.014	0.78%	anemometer calibration
$C_V$	1.000	-11.9%	0.100	1.19%	vertical reuptake
$L_c$	0.305m	+463%/m	500um	0.23%	characteristic length
$\varsigma$	6.00mm	+2632%/m	100um	0.26%	post height
$D_{PIR}$	25.4mm	-458%/m	1.0mm	0.46%	insulation thickness
$D_g$	1.00mm	-465%/m	500um	0.23%	air gap
$L_m$	3.57mm	+1067%/m	500um	0.53%	side metal strip width
$k_{PIR}$	22.2 $\frac{mW}{K \cdot m}$	+0.454%/ $\frac{mW}{K \cdot m}$	1.1 $\frac{mW}{K \cdot m}$	0.50%	PIR thermal conductivity
$\epsilon_{XPS}$	0.515	+30.0%	0.010	0.30%	XPS emissivity
$\epsilon_{tp}$	0.890	+36.1%	0.015	0.54%	tape emissivity
$\Omega_{tp}$	0.540	+24.5%	0.020	0.49%	tape coverage
$\epsilon_{rs}$	0.040	+126%	0.010	1.26%	test-surface emissivity
$\epsilon_{wt}$	0.900	+59.0%	0.025	1.47%	wind-tunnel emissivity
				4.05%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	57.3r/min	+0.390%/(r/min)	3.9r/min	1.51%	fan rotation rate
				5.05%	RSS combined uncertainty

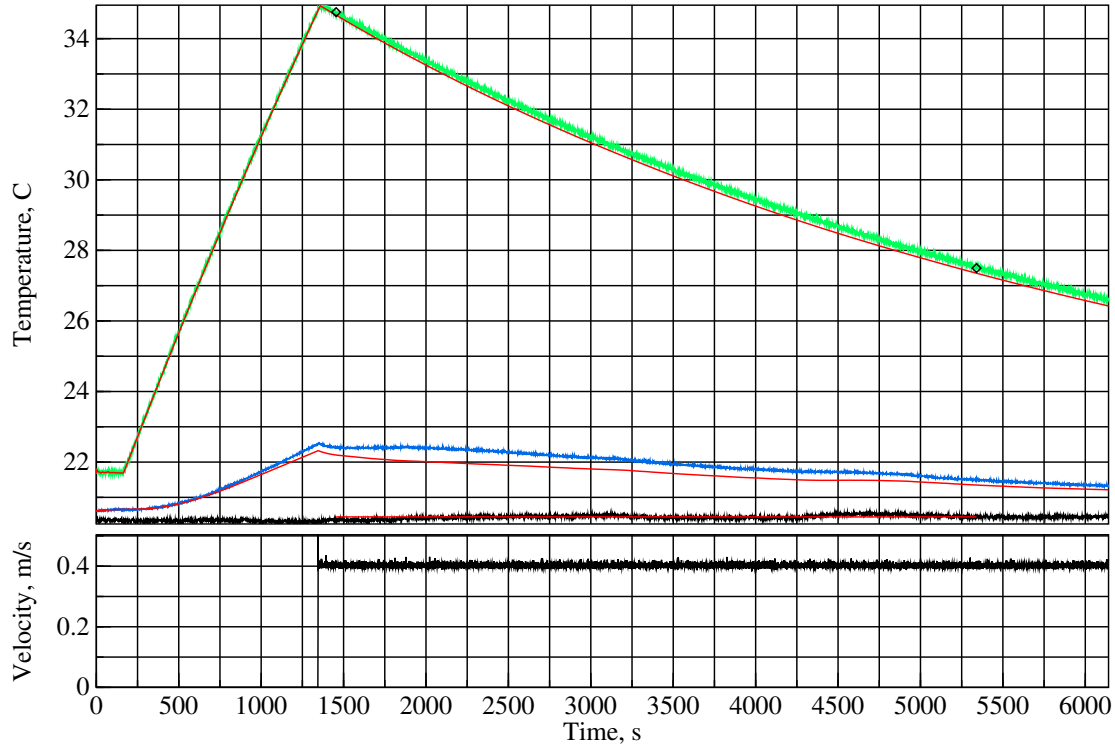
20160925T030035Z – mixed Convection – Roughness=3.00mm; T=20.7+10.5°C; +0.00°  
81±2.0r/min, V=0.29m/s, Re=5800, Ra/L^3=1.025x10^9, h=4.61W/(K.m^2), U=0.428W/K, Nu=54.7



Estimated measurement uncertainties, bi-level 3mm roughness at  $Re = 5799$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.5K	+19.0%/K	0.10K	1.90%	LM35C differential
$P$	101kPa	+0.0008%/Pa	1.5kPa	1.25%	MPXH6115A6U air pressure
$C_{pt}$	4.69kJ/K	+0.038%/(J/K)	47J/K	1.77%	plate thermal capacity
$\eta$	0.401	+105%	0.014	1.48%	anemometer calibration
$C_V$	1.000	−10.7%	0.100	1.07%	vertical reuptake
$L_c$	0.305m	+425%/m	500um	0.21%	characteristic length
$\varsigma$	6.00mm	+3824%/m	100um	0.38%	post height
$D_{PIR}$	25.4mm	−443%/m	1.0mm	0.44%	insulation thickness
$D_g$	1.00mm	−449%/m	500um	0.22%	air gap
$L_m$	3.57mm	+1002%/m	500um	0.50%	side metal strip width
$k_{PIR}$	22.2 $\frac{mW}{K \cdot m}$	+0.440%/ $\frac{mW}{K \cdot m}$	1.1 $\frac{mW}{K \cdot m}$	0.49%	PIR thermal conductivity
$\epsilon_{XPS}$	0.515	+27.1%	0.010	0.27%	XPS emissivity
$\epsilon_{tp}$	0.890	+32.6%	0.015	0.49%	tape emissivity
$\Omega_{tp}$	0.540	+22.1%	0.020	0.44%	tape coverage
$\epsilon_{rs}$	0.040	+114%	0.010	1.14%	test-surface emissivity
$\epsilon_{wt}$	0.900	+53.1%	0.025	1.33%	wind-tunnel emissivity
				4.03%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	80.6r/min	+0.525%/(r/min)	2.0r/min	1.06%	fan rotation rate
				4.55%	RSS combined uncertainty

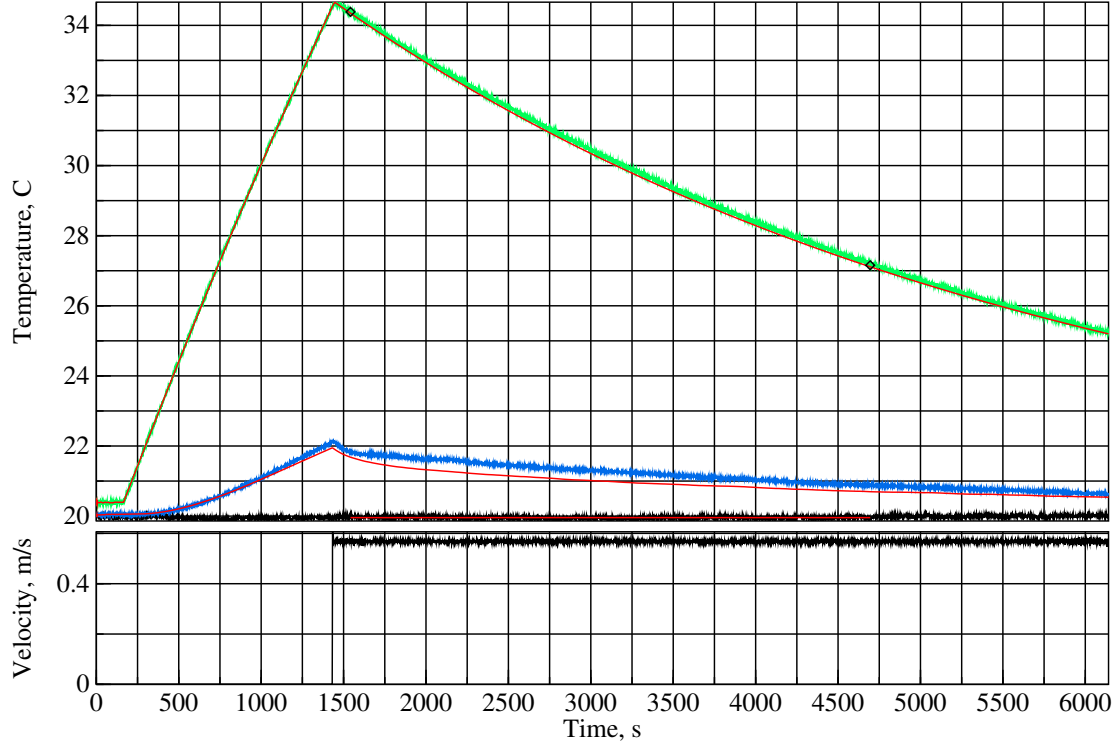
20160925T152635Z – mixed Convection – Roughness=3.00mm; T=20.4+10.2°C; +0.00°  
113±1.8r/min, V=0.40m/s, Re=8163, Ra/L^3=1.007x10^9, h=5.51W/(K.m^2), U=0.512W/K, Nu=65.5



Estimated measurement uncertainties, bi-level 3mm roughness at  $Re = 8163$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.2K	+17.3%/K	0.10K	1.73%	LM35C differential
$P$	101kPa	+0.0009%/Pa	1.5kPa	1.41%	MPXH6115A6U air pressure
$C_{pt}$	4.69kJ/K	+0.035%/(J/K)	47J/K	1.64%	plate thermal capacity
$\eta$	0.401	+178%	0.014	2.51%	anemometer calibration
$C_V$	1.000	−8.86%	0.100	0.89%	vertical reuptake
$\varsigma$	6.00mm	+5446%/m	100um	0.54%	post height
$D_{PIR}$	25.4mm	−390%/m	1.0mm	0.39%	insulation thickness
$L_m$	3.57mm	+886%/m	500um	0.44%	side metal strip width
$k_{PIR}$	22.2 $\frac{mW}{K \cdot m}$	+0.389%/ $\frac{mW}{K \cdot m}$	1.1 $\frac{mW}{K \cdot m}$	0.43%	PIR thermal conductivity
$\epsilon_{XPS}$	0.515	+22.4%	0.010	0.22%	XPS emissivity
$\epsilon_{tp}$	0.890	+26.9%	0.015	0.40%	tape emissivity
$\Omega_{tp}$	0.540	+18.2%	0.020	0.36%	tape coverage
$\epsilon_{rs}$	0.040	+94.3%	0.010	0.94%	test-surface emissivity
$\epsilon_{wt}$	0.900	+43.7%	0.025	1.09%	wind-tunnel emissivity
				4.26%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	113r/min	+0.632%/(r/min)	1.8r/min	1.17%	fan rotation rate
				4.86%	RSS combined uncertainty

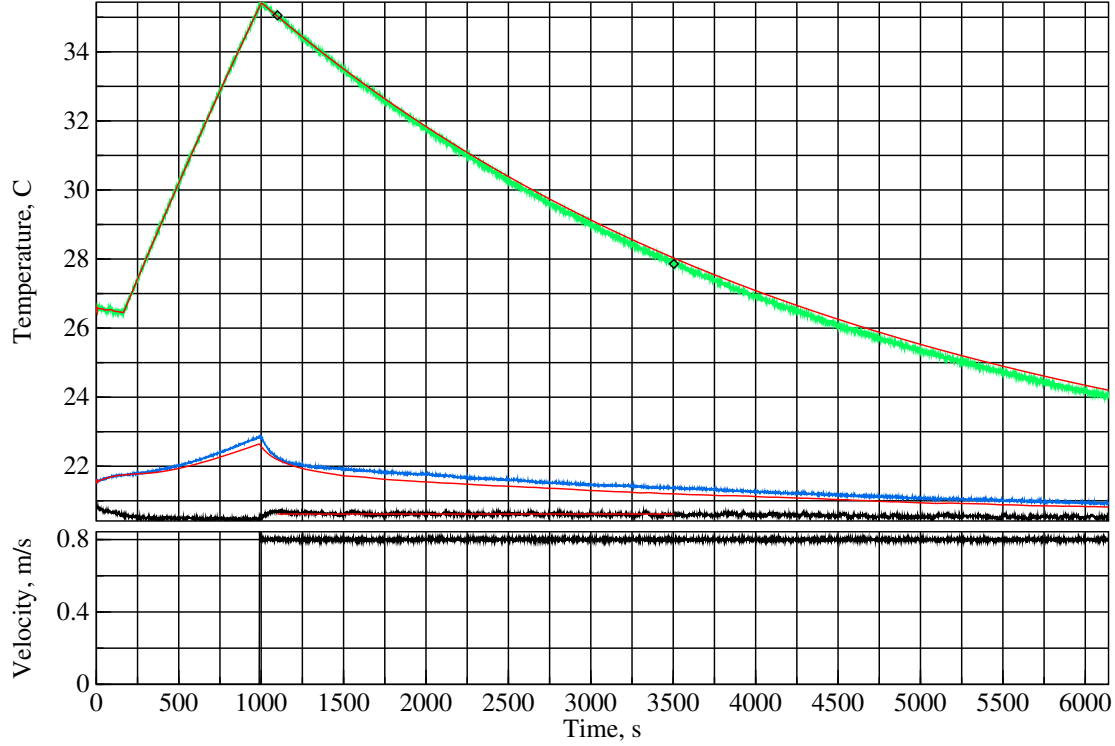
20160925T121827Z – mixed Convection – Roughness=3.00mm; T=20.0+10.4°C; +0.00°  
160±0.9r/min, V=0.57m/s, Re=11558, Ra/L^3=1.033x10^9, h=7.45W/(K.m^2), U=0.693W/K, Nu=88.7



Estimated measurement uncertainties, bi-level 3mm roughness at  $Re = 11557$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.4K	+14.9%/K	0.10K	1.49%	LM35C differential
$P$	101kPa	+0.0010%/Pa	1.5kPa	1.50%	MPXH6115A6U air pressure
$C_{pt}$	4.69kJ/K	+0.032%/(J/K)	47J/K	1.49%	plate thermal capacity
$\eta$	0.401	+226%	0.014	3.18%	anemometer calibration
$C_V$	1.000	-6.70%	0.100	0.67%	vertical reuptake
$\varsigma$	6.00mm	+6557%/m	100um	0.66%	post height
$D_{PIR}$	25.4mm	-308%/m	1.0mm	0.31%	insulation thickness
$L_m$	3.57mm	+734%/m	500um	0.37%	side metal strip width
$k_{PIR}$	22.2 $\frac{mW}{K \cdot m}$	+0.309%/ $\frac{mW}{K \cdot m}$	1.1 $\frac{mW}{K \cdot m}$	0.34%	PIR thermal conductivity
$\epsilon_{tp}$	0.890	+20.1%	0.015	0.30%	tape emissivity
$\Omega_{tp}$	0.540	+13.6%	0.020	0.27%	tape coverage
$\epsilon_{rs}$	0.040	+70.8%	0.010	0.71%	test-surface emissivity
$\epsilon_{wt}$	0.900	+32.7%	0.025	0.82%	wind-tunnel emissivity
				4.42%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	160r/min	+0.568%/(r/min)	0.95r/min	0.54%	fan rotation rate
				4.55%	RSS combined uncertainty

20160925T224429Z – mixed Convection – Roughness=3.00mm; T=20.6+10.4°C; +0.00°  
226±1.0r/min, V=0.80m/s, Re=16208, Ra/L^3=1.021x10^9, h=10.8W/(K.m^2), U=1.00W/K, Nu=127.8

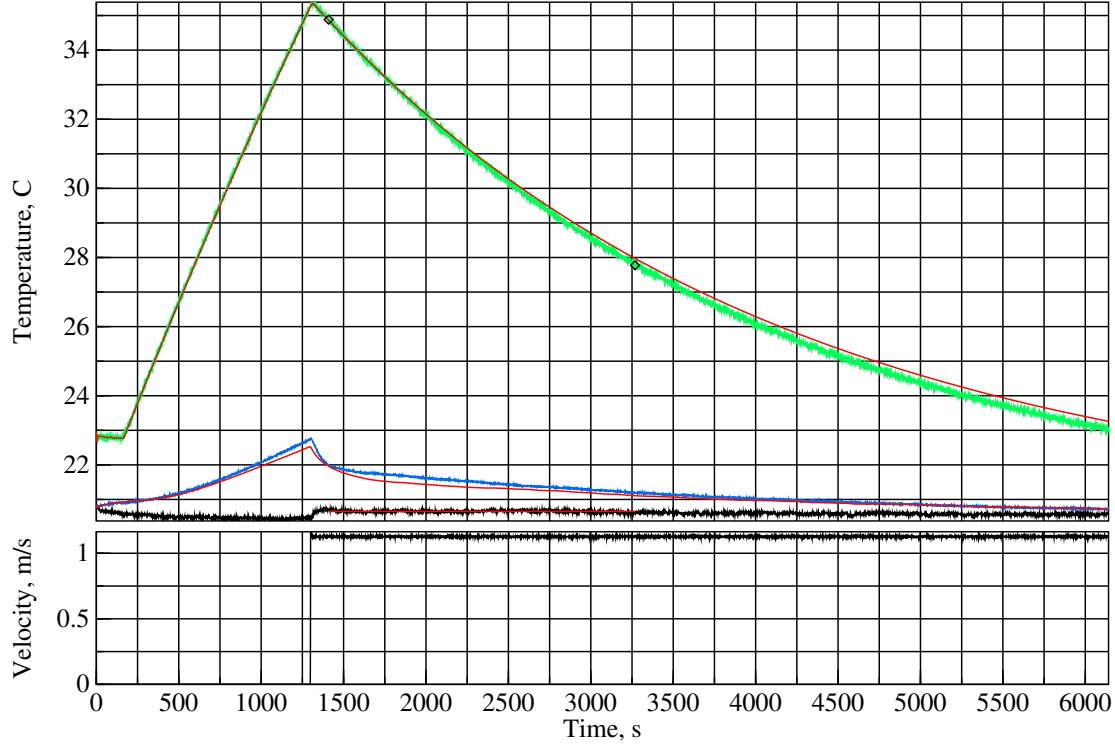


Estimated measurement uncertainties, bi-level 3mm roughness at  $Re = 16212$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.4K	+13.4%/K	0.10K	1.34%	LM35C differential
$P$	101kPa	+0.0010%/Pa	1.5kPa	1.52%	MPXH6115A6U air pressure
$C_{pt}$	4.69kJ/K	+0.029%/(J/K)	47J/K	1.36%	plate thermal capacity
$\eta$	0.401	+242%	0.014	3.39%	anemometer calibration
$C_V$	1.000	-4.86%	0.100	0.49%	vertical reuptake
$\varsigma$	6.00mm	+6964%/m	100um	0.70%	post height
$D_{PIR}$	25.4mm	-233%/m	1.0mm	0.23%	insulation thickness
$L_m$	3.57mm	+611%/m	500um	0.31%	side metal strip width
$k_{PIR}$	22.2 $\frac{mW}{K \cdot m}$	+0.235%/ $\frac{mW}{K \cdot m}$	1.1 $\frac{mW}{K \cdot m}$	0.26%	PIR thermal conductivity
$\epsilon_{tp}$	0.890	+14.7%	0.015	0.22%	tape emissivity
$\epsilon_{rs}$	0.040	+51.7%	0.010	0.52%	test-surface emissivity
$\epsilon_{wt}$	0.900	+23.8%	0.025	0.60%	wind-tunnel emissivity
				4.39%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	226r/min	+0.429%/(r/min)	1.0r/min	0.45%	fan rotation rate
				4.48%	RSS combined uncertainty



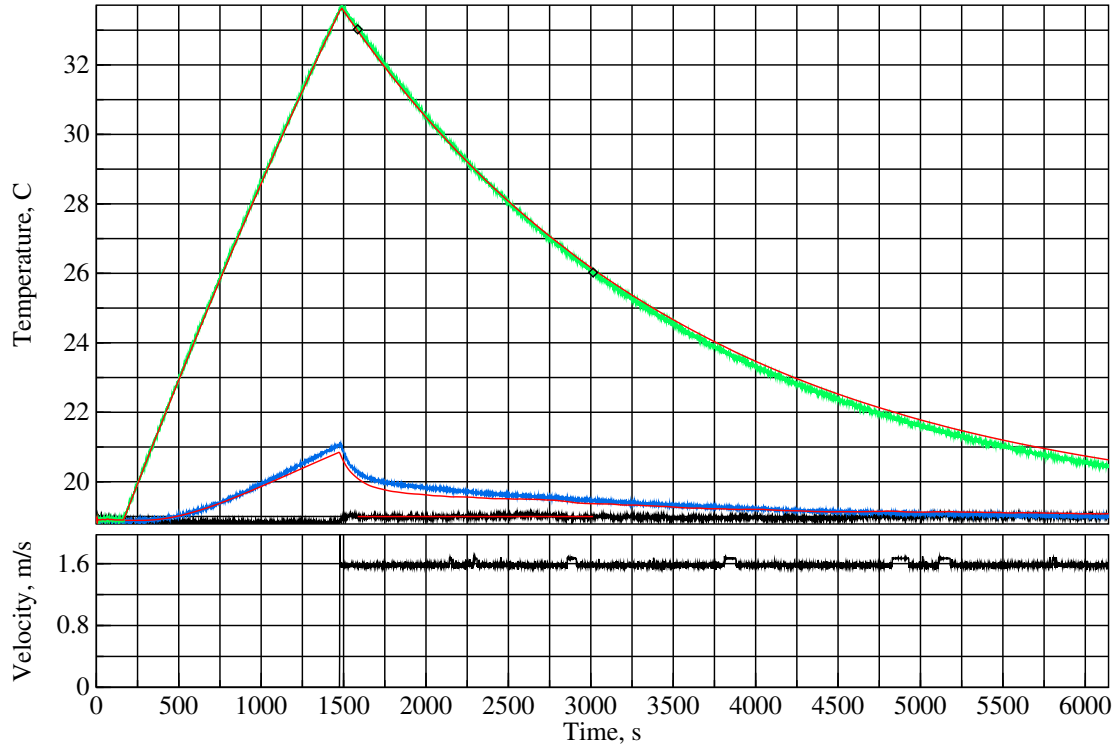
20160926T005344Z – mixed Convection – Roughness=3.00mm; T=20.7+10.3°C; +0.00°  
320±1.0r/min, V=1.1m/s, Re=22872, Ra/L^3=1.012x10^9, h=14.9W/(K.m^2), U=1.39W/K, Nu=177.5



Estimated measurement uncertainties, bi-level 3mm roughness at  $Re = 22871$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.3K	+12.5%/K	0.10K	1.25%	LM35C differential
$P$	101kPa	+0.0010%/Pa	1.5kPa	1.51%	MPXH6115A6U air pressure
$C_{pt}$	4.69kJ/K	+0.027%/(J/K)	47J/K	1.26%	plate thermal capacity
$\eta$	0.401	+243%	0.014	3.41%	anemometer calibration
$C_V$	1.000	-3.46%	0.100	0.35%	vertical reuptake
$\varsigma$	6.00mm	+7159%/m	100um	0.72%	post height
$L_m$	3.57mm	+515%/m	500um	0.26%	side metal strip width
$\epsilon_{rs}$	0.040	+36.9%	0.010	0.37%	test-surface emissivity
$\epsilon_{wt}$	0.900	+16.9%	0.025	0.42%	wind-tunnel emissivity
				4.28%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	320r/min	+0.305%/(r/min)	1.0r/min	0.31%	fan rotation rate
				4.32%	RSS combined uncertainty

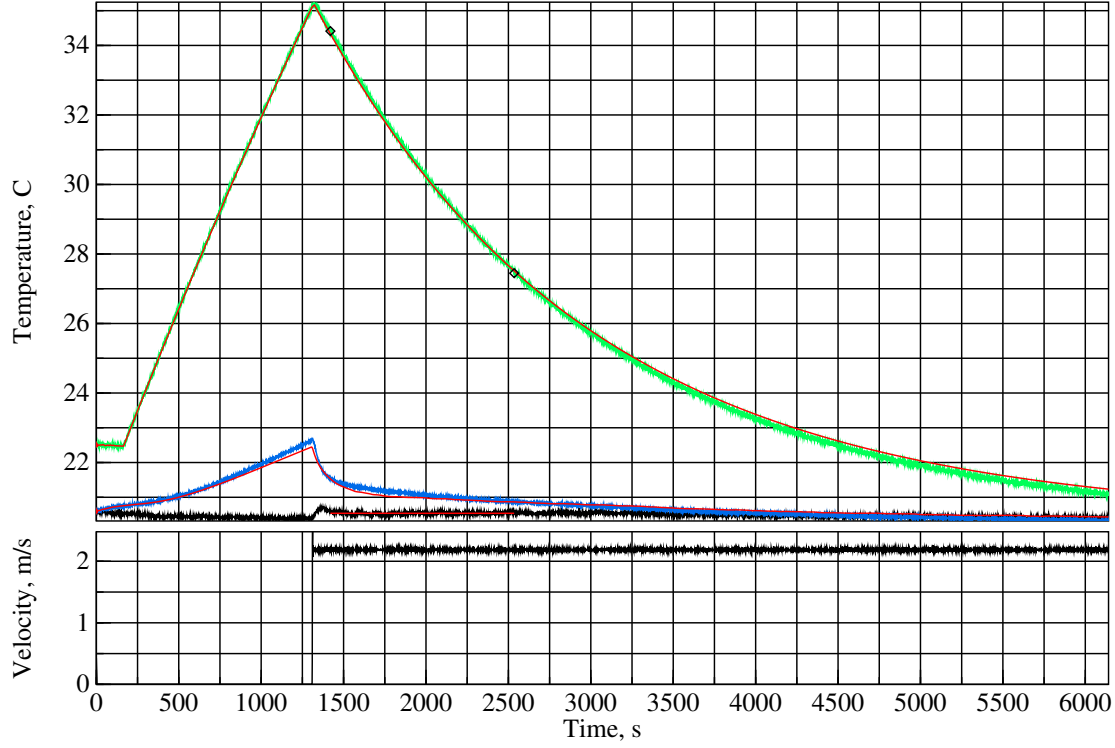
20161005T234155Z – mixed Convection – Roughness=3.00mm; T=19.0+10.2°C; +0.00°  
455±8.6r/min, V=1.6m/s, Re=32633, Ra/L^3=1.034x10^9, h=20.5W/(K.m^2), U=1.90W/K, Nu=244.4



Estimated measurement uncertainties, bi-level 3mm roughness at  $Re = 32631$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.2K	+11.9%/K	0.10K	1.19%	LM35C differential
$P$	102kPa	+0.0010%/Pa	1.5kPa	1.47%	MPXH6115A6U air pressure
$C_{pt}$	4.69kJ/K	+0.025%/(J/K)	47J/K	1.18%	plate thermal capacity
$\eta$	0.401	+235%	0.014	3.30%	anemometer calibration
$C_V$	1.000	-2.45%	0.100	0.25%	vertical reuptake
$\varsigma$	6.00mm	+7680%/m	100um	0.77%	post height
$L_m$	3.57mm	+444%/m	500um	0.22%	side metal strip width
$\epsilon_{rs}$	0.040	+25.7%	0.010	0.26%	test-surface emissivity
$\epsilon_{wt}$	0.900	+11.7%	0.025	0.29%	wind-tunnel emissivity
				4.10%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	455r/min	+0.207%/(r/min)	8.6r/min	1.77%	fan rotation rate
				5.42%	RSS combined uncertainty

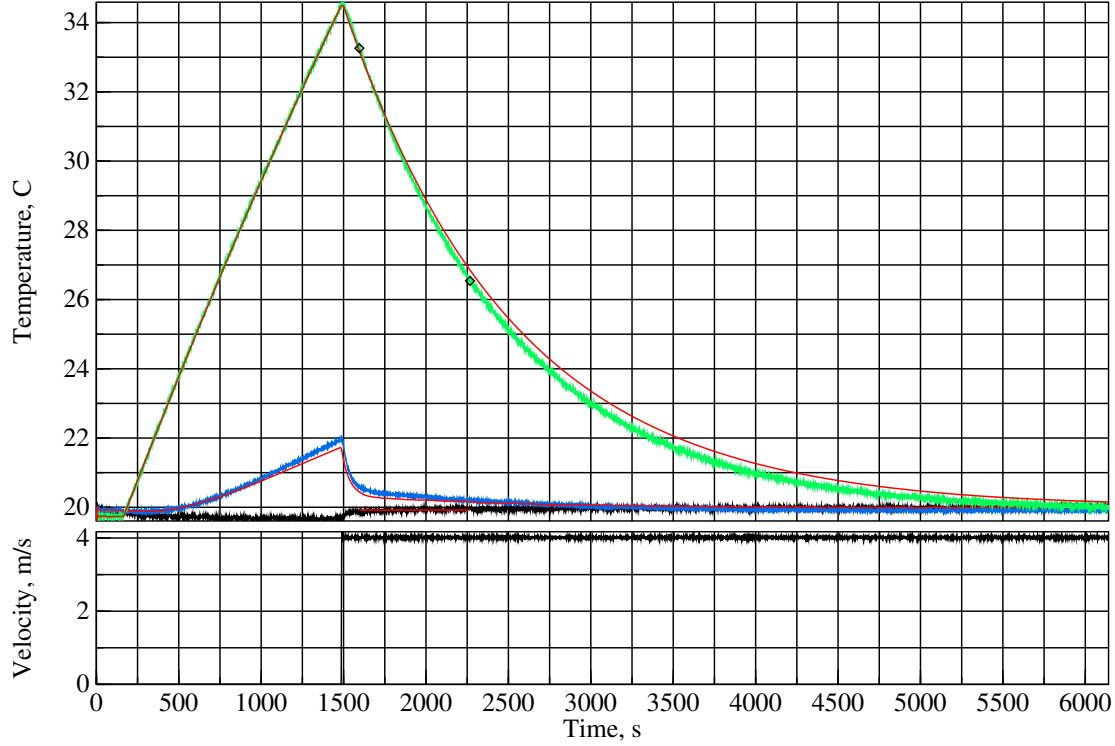
20160926T024524Z – mixed Convection – Roughness=3.00mm; T=20.5+10.0°C; +0.00°  
640±4.5r/min, V=2.2m/s, Re=44432, Ra/L^3=0.991x10^9, h=27.6W/(K.m^2), U=2.57W/K, Nu=327.7



Estimated measurement uncertainties, bi-level 3mm roughness at  $Re = 44430$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	10.0K	+11.6%/K	0.10K	1.16%	LM35C differential
$P$	101kPa	+0.0009%/Pa	1.5kPa	1.39%	MPXH6115A6U air pressure
$C_{pt}$	4.69kJ/K	+0.024%/(J/K)	47J/K	1.14%	plate thermal capacity
$\eta$	0.401	+214%	0.014	3.00%	anemometer calibration
$\varsigma$	6.00mm	+9128%/m	100um	0.91%	post height
$L_m$	3.57mm	+405%/m	500um	0.20%	side metal strip width
$\epsilon_{wt}$	0.900	+8.77%	0.025	0.22%	wind-tunnel emissivity
				3.83%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	640r/min	+0.134%/(r/min)	4.5r/min	0.61%	fan rotation rate
				4.02%	RSS combined uncertainty

20160926T230307Z – mixed Convection – Roughness=3.00mm; T=19.9+09.6°C; +0.00°  
1280±8.0r/min, V=4.0m/s, Re=81433, Ra/L^3=0.950x10^9, h=47.8W/(K.m^2), U=4.44W/K, Nu=568.7



Estimated measurement uncertainties, bi-level 3mm roughness at  $Re = 81443$ .

Symbol	Nominal	Sensitivity	Bias	Uncertainty	Component
$\Delta T$	9.61K	+11.4%/K	0.10K	1.14%	LM35C differential
$P$	101kPa	+0.0008%/Pa	1.5kPa	1.16%	MPXH6115A6U air pressure
$C_{pt}$	4.69kJ/K	+0.023%/(J/K)	47J/K	1.09%	plate thermal capacity
$\eta$	0.401	+142%	0.014	1.99%	anemometer calibration
$u_u$	7.787	+2.64%	0.100	0.26%	diffuser airflow upper bound
$\varsigma$	6.00mm	+12490%/m	100um	1.25%	post height
				3.09%	combined bias uncertainty
Symbol	Nominal	Sensitivity	Variability	Uncertainty	Component
$\omega$	1.28kr/min	+0.052%/(r/min)	8.0r/min	0.42%	fan rotation rate
				3.20%	RSS combined uncertainty