TEST REPORT No.49

16 June 2019

CHILLER EFFICIENCY PERFORMANCE WITH THE INTELLIGENT ADIABATIC CHILLER-BOOSTING **SMART COOLING™** PRO 10 SYSTEM

Test Participants

Istituto Nazionale di Ricerca Metrologica

Customer: INRIM

Installer: D'Ambrosio

Swiss Integrated Energy Technologies: Luca Gallarate

Project name: Istituto Nazionale di Ricerca Metrologica Torino

Structure location: Str. delle Cacce, 91, 10135 Torino TO, Italy

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Introduction

Type of structure: INRIM Site Torino, Italy.

Cooling equipment: TRANE RTAF 310 chiller.

Cooling capacity by manufacturer's data performance sheet: 1074 kw

Chiller booster: **Smart Cooling™** PRO 10 – adiabatic technology with condenser protection.

Cooling equipment at the INRIM site has been retrofitted to reduce energy consumption and increase Coefficient of Performance (COP) efficiency. The chillers were equipped with the intelligent adiabatic **Smart Cooling™** PRO 10 system.

The intelligent adiabatic **Smart Cooling™** system combines an adiabatic evaporative pre-cooling process and condenser protection with mechanical air filtration. The intelligent adiabatic **Smart Cooling™** system is mounted externally in front of the condensers of the cooling equipment. **Smart Cooling™** initiates the adiabatic process even before the mechanical cooling kicks in and the equipment receives a temperature-reducing fine mist of processed water that reduces the temperature of condensation within the cooling circuit.

Main components

Smart Cooling™ comprises the following key components: protective membranes, water treatment and recirculation systems, high-pressure water pump, control unit, high-pressure nozzle panels, fasteners and fixings.

Protective membranes are installed outside the condenser and cover its entire surface, preventing water mist from coming into direct contact with the condenser.

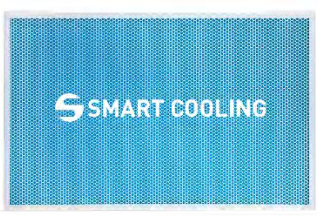
Water filtration, purification and sterilization: the system purifies water from minerals and sterilizes water to prevent bacterial occurrence.

A high-pressure pump provides water pressure of up to 70 bar while a water recirculation system reintroduces non-evaporated water into the water purification and pump system.

The control unit regulates the system according to real-time data sets such as chiller parameters, ambient air temperature and humidity to supply the adiabatic system with the appropriate amount of water.

A high-pressure nozzle provides water spray with 5- to 40-micron droplets.

A set of fasteners and fixings ensure the compatibility of the equipment with the chiller.




Chiller without **Smart Cooling™**

Chiller with **Smart Cooling™**

Equipment tested: **TRANE RTAF 310.**

Shown in picture No.2 are the chiller's condensers fully enveloped by **Smart Cooling's™** protective membranes, which prevent water damage infiltration and damage. On the foreground is the **Smart Cooling™** pump station, pumping meticulously treated water at a 70-bar pressure. The system is equipped with an automated Siemens controller. The system also includes a water drain line to re-filter and safely reuse water.

Picture No.2: chiller equipped with **Smart Cooling™**

Measurement instruments

The test was carried out with a RIELS RIF 600 W ultrasonic flow meter. The RIF 600 W sends and receives an ultrasound signal through a fluid located between two transductors. The instrument is placed on section of piping most suitable for data acquisition, which can be ascertained by the instrument itself.

The time difference between sending and receiving the signal through the fluid is directly proportional to the volumetric flow. The equipment was connected to the chiller pipes in order to verify the chiller's efficiency with the **Smart Cooling™** system turned on and off.

Energy consumption data was retrieved from cooling facilities' electrical substation.

The formula used for calculating the COP is: El/kW ÷ cooling/kW = COP

Testing Smart Cooling™

The test was performed on 15 June and 16 June 2019.

In performing the test, a RIELS (www.riels.it) ultrasound flow meter was used to record the flow of refrigerated water in the chiller, as well as the inlet and outlet water temperature.

For such purpose (in accordance with the specifications from RIELS) the insulation was removed from sections of the pipes and the sensors applied. Sensors were then covered with the insulation in order to avoid any possible temperature misreading by the probes caused by direct sunlight.

In any case, the flow meter is able to report any mistakes in installation and data reading. The equipment used on site was certified and calibrated, as documented on Annex 1.

The following data was provided by the customer's service provider:

- Piping outer diameter
- Piping thickness
- Piping material
- Refrigerated fluid type

With such data inputs the RIELS instrument returned the following readings:

15-06-19 12:50:00	Date and time
SYS:*R	SYS: sensors status - *R = sensors and OK readings
T1	Fluid inlet temperature
T2	Fluid outlet temperature
FLOW	Flow rate in m^3/h
VEL	Fluid velocity in m/s
EFR	Cooling power in kW/h (1 RT = 3,51685 kW)

For the same time period we asked the chiller's manufacturer, TRANE, to record energy consumption data (reported in Annex 2).

In order to record air temperature and relative humidity, a data logger was connected to the LOGO microprocessor that manages the **Smart Cooling™** system.

As a result of such operations, we retrieved the data reported in the table below, which shows:

- Date and time
- Compressors workload, in %
- Compressors energy consumption, in kW/h
- Theoretical COP at T=35°C as per TRANE's catalogue
- Cooling power in kW/h as reported by the RIELS equipment
- Real COP based on real cooling capacity and energy consumption
- Outdoor air temperature
- Outdoor relative humidity

Testing data

DATE / TIME	COMPRESSOR WORKLOAD (%)	ENERGY ABSORPTION (kWe/H)	THEORETICAL COP	THEORETICAL COOLING CAPACITY (KWf/H)	MEASURED COOLING CAPACITY (KWf/H)	MEASURED FLOW RATE (MC/H)	REAL COP	AIR TEMPERATURE (°C)	RELATIVE HUMIDITY (%)	COP INCREASE	COOLING CAPACITY INCREASE (kWf/H)	ENERGY SAVINGS (KWe/H)
15.06.2019 00:01	18,4%	59,9288	4,47	268,01	366,958	226,06	6,1232	27	53	1,6510	98,94	22,12
15.06.2019 01:01	20,6%	67,0942	4,64	311,60	382,239	227,005	5,6970	26	68	1,0528	70,64	15,21
15.06.2019 02:01	20,6%	67,0942	4,47	300,06	376,386	224,213	5,6098	27	63	1,1376	76,33	17,07
15.06.2019 03:01	18,8%	61,2316	4,47	273,84	355,15	225,281	5,8001	27	61	1,3279	81,31	18,18
15.06.2019 04:00	17,3%	56,3461	4,47	251,99	359,58	228,119	6,3816	27	54	1,9094	107,59	24,06
15.06.2019 05:00	18,4%	59,9288	4,31	258,44	344,656	225,966	5,7511	28	58	1,4386	86,21	19,99
15.06.2019 06:00	18,6%	60,5802	4,31	261,25	333,18	228,153	5,4998	28	54	1,1873	71,93	16,68
15.06.2019 07:00	1,8%	58,626	4,31	252,82	326,058	224,661	5,5617	28	55	1,2492	73,23	16,98
15.06.2019 08:00	18,8%	61,2316	4,31	264,06	358,563	228,757	5,8558	28	58	1,5433	94,50	21,91
15.06.2019 09:00	22,7%	73,9339	4,03	297,58	420,582	229,655	5,6886	30	55	1,6636	123,00	30,56
15.06.2019 10:00	21,7%	70,6769	3,66	258,61	374,396	227,992	5,2973	33	57	1,6382	115,78	31,64
15.06.2019 11:00	20,2%	65,7914	3,26	214,71	273,086	227,597	4,1508	37	51	0,8873	58,37	17,89
15.06.2019 12:00	27,0%	87,939	3,35	294,96	452,987	232,563	5,1512	36	50	1,7970	158,02	47,11
15.06.2019 13:00	41,1%	133,8627	3,35	449,00	659,277	228,444	4,9250	36	53	1,5709	210,28	62,69
15.06.2019 14:00	27,7%	90,2189	3,45	311,26	458,641	228,265	5,0836	35	54	1,6336	147,39	42,72
15.06.2019 15:00	26,8%	87,2876	3,35	292,78	433,102	229,71	4,9618	36	51	1,6076	140,32	41,84
15.06.2019 16:00	23,3%	75,8881	3,45	261,81	410,846	230,411	5,4138	35	49	1,9638	149,03	43,20
15.06.2019 17:00	0,0%	0		0,00	80,685	228,258	n.a.				80,69	
15.06.2019 18:00	32,8%	106,8296	3,55	379,40	557,796	229,883	5,2214	34	55	1,6699	178,39	50,23
15.06.2019 19:00	14,4%	46,9008	3,66	171,61	289,905	228,995	6,1812	33	47	2,5221	118,29	32,33
15.06.2019 20:00	26,2%	85,3334	3,66	312,24	465,645	228,572	5,4568	33	49	1,7977	153,40	41,92
15.06.2019 21:00	21,3%	69,3741	4,03	279,23	405,153	228,004	5,8401	30	51	1,8151	125,92	31,29
15.06.2019 22:00	20,8%	67,7456	4,16	282,08	428,859	255,044	6,3304	29	50	2,1666	146,78	35,25
15.06.2019 23:00	23,5%	76,5395	4,16	318,69	440,761	227,46	5,7586	29	55	1,5948	122,07	29,32
16.06.2019 00:00	18,4%	59,9288	4,47	268,01	350,706	227,84	5,8520	27	63	1,3798	82,69	18,49
16.06.2019 01:00	18,8%	61,2316	4,64	284,37	336,374	225,351	5,4935	26	68	0,8492	52,00	11,20
16.06.2019 02:00	19,4%	63,1858	4,64	293,45	344,166	229,876	5,4469	26	68	0,8027	50,72	10,92
16.06.2019 03:00	18,4%	59,9288	4,83	289,46	341,432	226,637	5,6973	25	69	0,8673	51,98	10,76
16.06.2019 04:00	19,4%	63,1858	4,83	305,19	365,148	225,046	5,7790	25	69	0,9490	59,96	12,41
16.06.2019 05:00	18,8%	61,2316	4,83	295,75	324,067	226,893	5,2925	25	72	0,4625	28,32	5,86
16.06.2019 05:59	16,9%	55,0433	4,64	255,63	304,482	227,24	5,5317	26	60	0,8875	48,85	10,52
16.06.2019 06:59	18,8%	61,2316	4,31	264,06	314,078	226,568	5,1293	28	65	0,8168	50,02	11,60
16.06.2019 07:59	18,2%	59,2774	3,90	230,90	292,61	228,494	4,9363	31	60	1,0411	61,71	15,84
16.06.2019 08:59	34,7%	113,0179	3,90	440,22	593,213	226,808	5,2488	31	65	1,3537	152,99	39,28
16.06.2019 09:59	34,7%	113,0179	3,66	413,54	425,639	225,898	3,7661	33	62	0,1070	12,10	3,31
16.06.2019 10:59	28,3%	92,1731	3,66	337,27	357,341	227,542	3,8768	33	60	0,2178	20,07	5,49
16.06.2019 11:59	31,0%	100,967	3,66	369,45	515,086	228,345	5,1015	33	50	1,4424	145,64	39,80
16.06.2019 12:59	39,8%	129,6286	3,55	460,37	581,142	193,753	4,4831	34	52	0,9317	120,77	34,01
16.06.2019 13:59	11,3%	36,8041	3,45	126,97	194,73	231,719	5,2910	35	45	1,8410	67,76	19,64
16.06.2019 14:59	13,8%	44,9466	3,26	146,68	225,835	196,043	5,0245	37	43	1,7610	79,15	24,25
16.06.2019 15:59	13,4%	43,6438	3,10	135,13	164,445	196,229	3,7679	39	41	0,6717	29,32	9,47
16.06.2019 16:59	12,8%	41,6896	3,45	143,83	212,003	227,927	5,0853	35	53	1,6353	68,17	19,76
16.06.2019 17:59	15,3%	49,8321	3,45	171,92	275,816	195,869	5,5349	35	48	2,0849	103,90	30,11
16.06.2019 18:59	34,9%	113,6693	3,26	370,96	566,794	227,904	4,9863	37	43	1,7228	195,83	60,01
16.06.2019 19:59	35,7%	116,2749	3,55	412,95	600,258	228,7	5,1624	34	55	1,6109	187,31	52,74
16.06.2019 20:59	24,6%	80,1222	3,66	293,17	429,412	227,921	5,3595	33	57	1,7004	136,24	37,23
16.06.2019 21:59	22,3%	72,6311	3,90	282,91	397,541	227,192	5,4734	31	65	1,5783	114,63	29,43
16.06.2019 22:59	22,1%	71,9797	4,03	289,72	413,556	228,55	5,7455	30	67	1,7205	123,84	30,77
16.06.2019 23:59	20,2%	65,7914	4,03	264,81	367,793	224,572	5,5903	30	72	1,5653	102,98	25,59
17.06.2019 00:59	22,1%	71,9797	4,03	289,72	408,854	225,978	5,6801	30	68	1,6551	119,14	29,60
17.06.2019 01:59	21,3%	69,3741	4,16	288,86	410,357	229,289	5,9151	29	65	1,7513	End of 2 days TEST	
17.06.2019 02:59	19,8%	64,4886	4,16	268,52	360,168	228,384	5,5850	29	65	1,4212		
17.06.2019 03:59	19,6%	63,8372	4,03	256,94	363,319	229,043	5,6913	30	61	1,6663		
17.06.2019 04:59	0,0%	0		0,00	27,5247	229,286	n.a.					
17.06.2019 05:59	22,9%	74,5853	4,16	310,56	431,337	228,699	5,7831	29	63	1,6193		
17.06.2019 06:59	26,8%	87,2876	3,90	340,00	350,367	230,349	4,0139	31	65	0,1188		
17.06.2019 07:58	19,4%	63,1858	3,55	224,40	363,891	229,457	5,7591	34	54	2,2076		

AVERAGE TOTAL	22,31%	70,45	3,96		374,81	226,1135	5,36	30,96	57,53	1,41		13 08,27

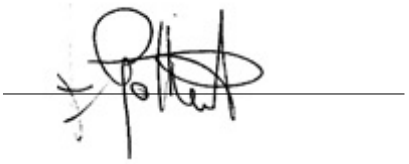
Conclusions

As a result of the test, in accordance with the data reported above, implementing the **Smart Cooling™** system has allowed the TRANE RTAF 310 chiller to increase its cooling capacity and simultaneously reduce energy consumption up to achieving a COP higher than 5 (at reference temperature = 35°C).

Testing during two days with compressor workload on 22.31% average showed:

Average COP increase	**1.41**
Electric energy consumption decreased by	**27%**
Average cooling capacity increased by	**37%**
Overall savings during test period	**1308.27kW**
Water consumption during test period	**23,51m³**
Return on Invesment	**6 months**

Luca Gallarate



16 June 2019

Annex

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RIF600 | Clamp-on Ultrasonic Meter Calibration Report

Pipe diameter	DN80	Date	15/12/2018
Ambient temperature	29°C		
Standard Device before test	Normal	Model:	RIF600W
Standard Devide After Test	Normal		
Test result	Qualified		
Measured Medium	Water		
Accuracy	1%		
Signal Strength	UP: 90		
	DOWN: 90		
Standard device name	Static volumetric method/standard Meter Method Water Flow/Standard Device		
Standard device accuracy	0,20%		

Test	Standard Meter flow		Temperature	Pressure	Tested Meter Flow		Basic Error		Repeatability	
Point	m3/h		°C	Mpa	m3/h		%		%	
Point 1	101,52	101,47	25,0	0,300	102,27	102,10	0,739	0,759	-0,147	0,147
	101,47		25,0	0,300	102,07		0,591			
	101,42		25,0	0,300	101,97		0,542			
Point 2	71,27	71,27	25,0	0,300	71,75	71,75	0,673		-0,146	
	71,19		25,0	0,300	71,65		0,646			
	71,34		25,0	0,300	71,86		0,729			
Point 3	26,32	26,36	25,0	0,300	26,51	26,55	0,722		-0,132	
	26,36		25,0	0,300	26,56		0,759			
	26,39		25,0	0,300	26,58		0,720			

Verification Based on JJG 1030-2007 < Ultrasonic flowmeter verification procedures >
Scale Factor=1

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RIF600 |Test Report misuratore di portata ad ultrasuoni clamp on

Diametro tubazione	DN80		Date	15/12/2018
Temperatura ambiente	29°C			
Dispositivo standard prima del test	Normale		Model:	RIF600W
Dispositivo standard dop il test	Normale			
Risultato del test	Qualified			
Liquido	Acqua			
Accuratezza	1%			
Potenza dei segnali	UP:	90		
	DOWN:	90		
Tipo di dispositivo standard	Metodo volumetrico statico/Misuratore di portata volumetrico			
Accuratezza del dispositivo standa	0,20%			

Test	Misuratore standard		Temperatura	Pressione	Misuratore testato		errore base		Ripetibilità	
Punti	m3/h		°C	Mpa	m3/h		%		%	
Punto 1	101,52	101,47	25,0	0,300	102,27	102,10	0,739	0,759	-0,147	0,147
	101,47		25,0	0,300	102,07		0,591			
	101,42		25,0	0,300	101,97		0,542			
Punto 2	71,27	71,27	25,0	0,300	71,75	71,75	0,673		-0,146	
	71,19		25,0	0,300	71,65		0,646			
	71,34		25,0	0,300	71,86		0,729			
Punto 3	26,32	26,36	25,0	0,300	26,51	26,55	0,722		-0,132	
	26,36		25,0	0,300	26,56		0,759			
	26,39		25,0	0,300	26,58		0,720			

Verification Based on JJG 1030-2007 < Ultrasonic flowmeter verification procedures >
Scale Factor=1

Annex 2

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Cusago Milano 20/09/2019

Spett.le D'Ambrosio Impianti srl,

Oggetto: Valutazione e incrocio dati di funzionamento gruppo refrigeratore GVAF310 s.n°ELB3311 e sistema adiabatico Smart Cooling.

A seguito dell'incontro avvenuto Lunedì 16 Settembre c/o la vostra sede situata in Via Germania 3 a Collegno To, per la valutazione e visione dei dati di funzionamento del gruppo GVAF310 s.n°ELB3311 installato c/o I.N.RI.M Strada Delle Cacce 92 di Torino.
Incrociando i dati rilevati dal sistema di gestione installato sul gruppo e i dati rilevati, nelle date del 15 e 16 Giugno 2019, dalla società Smart Cooling, fornitrice del sistema adiabatico installato sul gruppo refrigeratore, confermiamo i dati di funzionamento riportati nell'allegato.

Distinti saluti

Giroletti Stefano
Service Technician Coordinator & Quotation Engineer
Piemonte, Liguria and Valle D'Aosta