TEST REPORT: No.49

Date: June 16st 2019

CHILLER EFFICIENCY PERFORMANCE WITH INTELLIGENT ADIABATIC CHILLER BOOSTER SYSTEM "SMART COOLING™" PRO 10

Participated in the test:

Istituto Nazionale di Ricerca Metrologica

Customer: INRIM

Installer: " D'AMBROSIO"

Swiss Integrated Energy Technologies: Luca Gallarate

Project name: Istituto Nazionale di Ricerca Metrologica Torino, Italy

Object address: Str. delle Cacce, 91, 10135 Torino TO, Italy

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Introduction:

Type of building: INRIM Site Torino, Italy.

Cooling units: 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.

1-unit chiller retrofits were made to reduce the energy consumption of chillers and to increase chiller COP efficiency. Chillers were equipped with intelligent adiabatic pre-cooling system “Smart Cooling™” PRO 10. Chiller booster PRO 10 is based on pre-cooling of air before it enters condensers by using water evaporation technology - spraying and vaporising a very fine water mist before entering the condenser (hot air comes into contact with the fine water mist, the temperature of the incoming air in the condenser is reduced).

Chiller booster components ensure 100% condenser protection from direct contact with water. The water must not reach the condenser.

Main components:

The protective membranes: the membranes are installed outside before the condenser, covering 100% of the condenser surface, thus preventing the water mist from coming into direct contact with the condenser. Water filtration, water purification, water sterilisation: the system provides water purification from minerals and water sterilization to avoid the risk of bacterial occurrence.

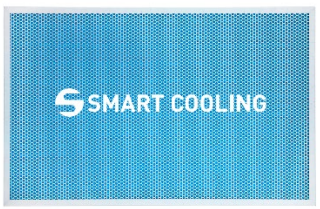
High pressure pump capable of providing water pressure up to 70 bar.

A water recirculation system that drains non-evaporated water into a water purification and pump system.

The control unit, which provides complete system control according to ambient air temperature and humidity, provides the complete operation of the system, analyses the parameters of the chiller, ambient air temperature and humidity, and provides the required amount of water in the adiabatic system according to data gathered.

A high-pressure nozzle panels that provide 5-40-micron droplet water spraying.

A set of fasteners and fixings ensuring the compatibility of the chiller booster system with the chiller.



Equipment tested: **TRANE RTAF 310 .**

Chiller without “Smart Cooling™” system

Chiller with “Smart Cooling™” system

In Picture No.2 it can be seen that the chiller condensers are fitted with protective membranes that prevent the water from entering the chiller condenser. Behind it is the chiller booster pump station, which includes 70 bar water preparation, water sterilization, purification. The equipment is equipped with a programmable Siemens controller. The right side of the chiller shows the water drain line connected to the pump station. The water that enters the drain is re-filtered and reused.

(Picture No.2 Chiller equipped with “Smart Cooling™” system)

Measuring instruments:

The test was carried on through a RIELS RIF 600 W ultrasonic flow meter. The RIF 600 W works by sending and receiving an ultrasound signal through a fluid between two transductors, placed on a pipe in a location determined by the instrument itself in accordance with the application.

The time difference between sending and receiving the signal through the fluid is directly proportional to it velocity and thus to the volumetric flow. The equipment was connected to the pipes of the chiller in order to verify the efficiency with both the SMART COOLING™ system on and off.

Energy consumption data were retrieved from the equipment in the electrical substation.

The formula for calculating the COP. EI/kw ÷ cooling / kw = cop

Test of 'Smart Cooling™' equipment:

The test was performed on June 15th and 16th, 2019

In performing the test, a RIELS (www.riels.it) ultrasound flow meter has been 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 has been removed from part of the pipes and the sensors applied. Sensors have been then covered with the insulation in order to avoid any possible temperature misreading by the probes, caused by direct sunlight.

The flow meter in any case is able to report any mistake in installation and data reading. The equipment has been certified and calibrated (Annex 4).

The following data, necessary in order to correctly run the flow meter, have been provided by the customer's service provider:

- Outer diameter of the pipes;
- Thickness of the pipes;
- Material used for the pipes;
- Type of refrigerated fluid.

With such inputs data, the RIELS instrument returned the following data

19-10-15 12:50:00	Date and time
SYS:*R	SYS: sensors status - *R = sensors and OK readings
T1	Inlet temperature of the fluid
T2	Outlet temperature of the fluid
FLOW	Flow rate in m³/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 manufacturer TRANE to record the energy consumption data (reported in Annex 2)

In order to record air temperature and relative humidity, a Data Logger has been connected to the LOGO microprocessor that manages the Smart Cooling™ system.

As a result of such operations, we retrieved the data reported in Annex 3. The table reported

- Date and time
- Workload of the compressors in %
- Energy consumption of the compressors in kW/h
- Theoretical COP at T=35°C as per TRANE catalogue
- Cooling power in kW/h as reported by the RIELS equipment
- Real COP calculated upon the real cooling capacity and energy consumption
- Outdoor air temperature
- Outdoor relative humidity

Test data:

DATE / TIME	COMPRESSORS POWER (%)	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 SAVING (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	22,31%	70,45	3,96		374,81	226,1135	5,36	30,96	57,53	1,41		13 08,27

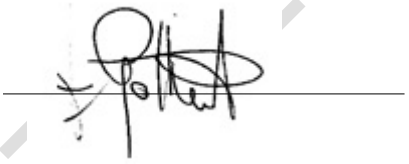
Conclusions

As a result of the test, in accordance with the data reported in Annex 3, implementing the Smart Cooling™ system allowed the TRANE RTAF 310 chiller to increase its cooling capacity and at the same time to reduce the energy consumption up to achieving a COP (at reference temperature = 35°C) higher than 5.

Test in two days with compressor power on 22,31% average:

Average COP increase	1,41
Electric energy consumption reduced by	27%
Average cooling capacity increased by	37%
Overall saving during test period	1308,27kW
Water consumption during test period	23,51m³
ROI	6 months

Luca Gallarate



June 16st 2019

Annex

Riels instruments srl
Viale Spagna, 16
35020 Ponte San Nicolò (PD) - ITALY
Ph. +39 0498961771 | info@riels.it

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

Riels instruments srl
Viale Spagna, 16
35020 Ponte San Nicolò (PD) - ITALY
Ph. +39 0498961771 | info@riels.it

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

Trane Italia srl
Viale Europa, 30/c2
20090 Cusago (MI)
Tel +39 02.90.335.1
Fax +39 02.90.335.901
www.trane.com

Filiale di Roma
Via Ercolano Salvi 12 , Int. 6
00143 Roma
Tel +39 06.59.6495.1
Fax serv. +39 06.59.6495.49
Fax com. +39 06.59.6495.39

Filiale di Padova
Viale Europa 14/A
35020 Ponte San Nicolò
Padova

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