Certificazioni
Centrale Termoelettrica di Termoli

BS OHSAS 18001:2007 CERTIQUALITY SISTEMA DI GESTIONE SICUREZZA CERTIFICATO

UNI EN ISO 14001:2004 CERTIQUALITY SISTEMA DI GESTIONE AMBIENTALE CERTIFICATO

EMAS GESTIONE AMBIENTALE VERIFICATA reg. n. IT-000992

SORGENIA POWER

Ministero dell'Ambiente e della Tutela del Territorio e del Mare – Direzione Generale Valutazioni Ambientali

E.prot DVA-2011-0030486 del 05/12/2011

Spett.le MINISTERO DELL'AMBIENTE E DELLA TUTELA DEL TERRITORIO E DEL MARE
Direzione Generale per le Valutazioni Ambientali – Div. IV – AIA
Via C. Colombo, 44
00147 Roma

c.a. Dr. Giuseppe Lo Presti

e p.c. **ISPRA**
Via V. Brancati, 48
00144 Roma

MINISTERO DELL'AMBIENTE E DELLA TUTELA DEL TERRITORIO E DEL MARE DIREZIONE GENERALE ... RICEVUTO IL 02 DIC. 2011

MINISTERO DELL'AMBIENTE E DELLA ... VALUTAZIONI AMBIENTALI DIREZIONE GE... 02 DIC...

Prot. n. TER/PA/GM/2011/0042

Milano, 18/11/2011

OGGETTO: ***Decreto DVA-DEC-2011-0000299 del 7/6/2011 Autorizzazione Integrata Ambientale per l'esercizio della Centrale Termoelettrica della società Sorgenia Power S.p.A. sita nel comune di Termoli (CB) - Richiesta di modifica prescrizione.***

Con riferimento alla prescrizione riportata a pag. 95 del Parere Istruttorio conclusivo e Tabella 6 del Piano di Monitoraggio e Controllo di cui all'Autorizzazione in oggetto e che per chiarezza si riporta di seguito:

"In relazione ai due turbogas il Gestore dovrà effettuare le misurazioni in continuo [...omissis] della portata volumetrica dell'effluente gassoso". Le apparecchiature devono essere esercite e verificate [...omissis].

Tenuto conto che ISPRA, nella comunicazione Prot. Gen. ISPRA n. 36412 del 31/10/2011, individua in questo spett.le Ministero la competenza per la valutazione della richiesta della scrivente.

Considerato che:

- la portata volumetrica degli effluenti gassosi prodotti dalla combustione del gas naturale nelle turbine a gas della Centrale di Termoli viene attualmente misurata in modo "indiretto" ed in continuo secondo il metodo previsto dalla norma ISO-2314: 1989 (E) *"Gas turbines – Acceptance tests"*, diffusa in tutto il mondo per la valutazione delle prestazioni delle turbine a gas come espressamente riportato nella relazione tecnica **RTC DIR 003 TE** *"GT Exhaust gas flowrate calculation according to ISO 2314 Code"*.
- In fase progettuale Sorgenia preferì utilizzare il sistema di calcolo in quanto, per la tipologia di impianto e per le caratteristiche fisiche dei camini della centrale, garantiva un grado di precisione confrontabile se non più accurato di quello dei misuratori di portata ad ultrasuoni. Tale parametro, tenuto conto del fatto che il decreto autorizzativo allora in vigore non prescriveva alcuna misura sul parametro portata fumi, era utilizzato da Sorgenia come parametro conoscitivo per calcolare le prestazioni della turbina a gas.

Si richiede la possibilità di ottemperare alla prescrizione di cui sopra prevedendo, in sostituzione della misura in continuo della portata volumetrica dell'effluente gassoso, il calcolo della stessa secondo la metodica attualmente in uso.

Si riportano in allegato alla presente:

- Relazione tecnica **RTC DIR 003 TE** *"GT Exhaust gas flowrate calculation according to ISO 2314 Code"*
- Comunicazione Protocollo Generale ISPRA n. 36412 del 31/10/2011 indirizzata alla scrivente e recante chiarimenti in merito all'attuazione del Piano di Monitoraggio e Controllo facente parte del Decreto DVA-DEC-2011-0000299 del 7/6/2011.

In attesa di riscontro si resta a disposizione per eventuali chiarimenti in merito.

Con osservanza.

Sorgenia Power S.p.A.
L'amministratore delegato
Ing. Alberto Bigi

ISPRA
PROTOCOLLO GENERALE
Nr.0036412 Data 31/10/2011
Tit X° Partenza

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

TRASMISSIONE VIA FAX

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RIFERIMENTO: Decreto DVA-DEC-2011-0000299 del 07/06/2011 di autorizzazione integrata ambientale con avviso pubblicato su G.U. n° 148 del 28/06/2011, per l'esercizio della impianto turbogas della Società Sorgenia Power SpA sita nel comune di Termoli (CB).

OGGETTO: Vostre nota prot. TER/PA/SG/2011/0022 del 29/06/2011, acquisita da ISPRA con prot.22932 dell'11/07/2011, nonché Vostre richieste di chiarimento acquisite da ISPRA con prot.28669 del 01/09/2011. Definizione delle modalità tecniche e tempistiche più adeguate all'attuazione del piano di monitoraggio e controllo (PMC).

In relazione alle richieste di chiarimento in oggetto, informata ARPA Molise, si rappresenta quanto di seguito indicato.

Punto 2 – In merito alla misura in continuo della portata volumetrica dell'effluente gassoso, prescritta (pag.95) dal Parere Istruttorio (PI), con le modalità riportate nella Tabella 6 del PMC (pag.9), si evidenzia che gli enti di controllo (ISPRA/ARPA Molise) non sono competenti ad approvare alcuna modifica del corpo prescrittivo contenuto nell'intero atto autorizzativo e pertanto si invita Codesta Società a voler formalizzare con l'Autorità Competente specifica istanza di modifica della disposizione sopra indicata.

Punto 3 – In merito alla misura delle emissioni nei periodi transitori, nel prendere atto della richiesta di utilizzare il metodo indiretto previsto dalla norma ISO 2314 per il calcolo dei volumi dei fumi, si evidenzia che il suddetto metodo dovrà essere descritto nell'ambito del più ampio piano di monitoraggio dei transitori prescritto al paragrafo 9.3.1, pag. 95, punto 4) del PI. Al riguardo, si rappresenta che si resta in attesa di una proposta del citato piano di monitoraggio dei transitori, il quale dovrà essere elaborato anche tenendo conto di quanto prescritto ai precedenti punti 1), 2) e 3) del medesimo paragrafo 9.3.1, pag. 95 e al paragrafo 4.1.2 del PMC, pagg. 11-12. Esso dovrà inoltre dettagliare:

- il fondo scala strumentale per la misura in continuo di ossidi di azoto NO_x e del monossido di carbonio CO che si intende utilizzare al fine di monitorare e quantificare le emissioni (cfr. pag. 95 punto 1), specificando, nel caso in cui si utilizzino i medesimi strumenti per il monitoraggio durante il normale funzionamento degli impianti, i due

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diversi range di misura relativi rispettivamente alle condizioni di normale funzionamento e alle condizioni di regime transitorio degli avvii/spegnimenti;
- la metodologia di indagine che consenta di valutare i transitori per le singole unità produttive, ancorché funzionanti per periodi dell'anno limitati.

Punto 4 - In considerazione dell'evidenziata misura della concentrazione degli inquinanti per mezzo di strumentazione di tipo estrattivo, ove l'analisi avvenga su campione disidratato (sistema di refrigerazione per disidratazione posto a monte dell'analizzatore), si ritiene accettabile la deroga richiesta anche in riferimento all'allegato II alla parte V del D. Lgs 152/2006, parte II, sezione 8, comma 1, che prevede l'assenza della misurazione in continuo del tenore di vapore, qualora l'effluente gassoso prelevato sia essiccato prima delle analisi delle emissioni.

Punto 5 – Relativamente all'individuazione delle aree di collocazione della rete piezometrica, si richiede di trasmettere la proposta definitiva di collocazione dei piezometri in tempi utili al fine di rispettare la tempistica di cui all'art. 3 comma 8 del Decreto di AIA per la collocazione dei piezometri e di avviare la caratterizzazione delle acque sotterranee sulla base del flusso effettivo di falda prevalente in base a quanto indicato dal PI a pag. 97 e dal PMC, § 6.2, pagg. 18-19.

Punto 6 – In riferimento al monitoraggio delle acque meteoriche non contaminate, si conferma il controllo prescritto nel PMC (pagg. 17-18), tramite campionamento manuale/strumentale con relative analisi di laboratorio, mantenendo la frequenza semestrale, solo in occasione di eventi meteorici con attivazione dello scarico SF2 al canale consortile. Sulla base di una prassi consolidata con l'Autorità Competente, che legge in copia, in circostanze analoghe, l'Autorità Competente ha peraltro manifestato la disponibilità a rivedere il corpo prescrittivo, su specifica istanza del gestore e sulla base di una valutazione di questo Istituto dei dati di monitoraggio, ad esito di un periodo di attuazione significativo valutato da questo Istituto, nel caso specifico, non inferiore ad un anno dal rilascio dell'autorizzazione in riferimento.

Infine, non essendo pervenute ulteriori osservazioni in merito alle modalità tecniche e alle tempistiche attuative del PMC, si ritiene conclusa la fase di cui al comma 1 dell'art. 3, del Decreto in riferimento, per la definizione del cronoprogramma di adeguamento e completamento del sistema di monitoraggio prescritto, considerando pienamente operativo l'intero PMC a partire dall'inizio dell'anno 2012.

Si ribadisce che tutta la documentazione destinata a questo Istituto, dovrà essere inoltrata in conformità alle modalità (punto D) indicate nella lettera ISPRA prot. 18712 del 1 giugno 2011.

Stante quanto sopra esposto, si ritiene superata la richiesta di incontro, salvo Vostro diverso intendimento e si rimane a disposizione per eventuali ulteriori approfondimenti.

Distinti saluti.

SERVIZIO INTERDIPARTIMENTALE
PER L'INDIRIZZO, IL COORDINAMENTO E IL
CONTROLLO DELLE ATTIVITA' ISPETTIVE
Il Responsabile
Ing. Alfredo Pini

energia operation

RELAZIONE TECNICA NR. - Technical relation nr.	AUTORE – Compiled by
RTC003	**Gregorini Nicola**

OGGETTO – Object

GT EXHAUST GAS FLOWRATE CALCULATION ACCORDING TO ISO 2314 CODE

REV.	DATA – Issue data	DESCRIZIONE REV. – Description rev.	NOTE – Notes
x	15/02/05	Issued	15/02/05

SUMMARY

1. SCOPE

This technical report summarizes the calculation procedure according to code ISO 2314 to properly evaluate the exhaust gas flowrate produced by the gas turbine and vented from top of exhaust stack.

2. REFERENCE CODE

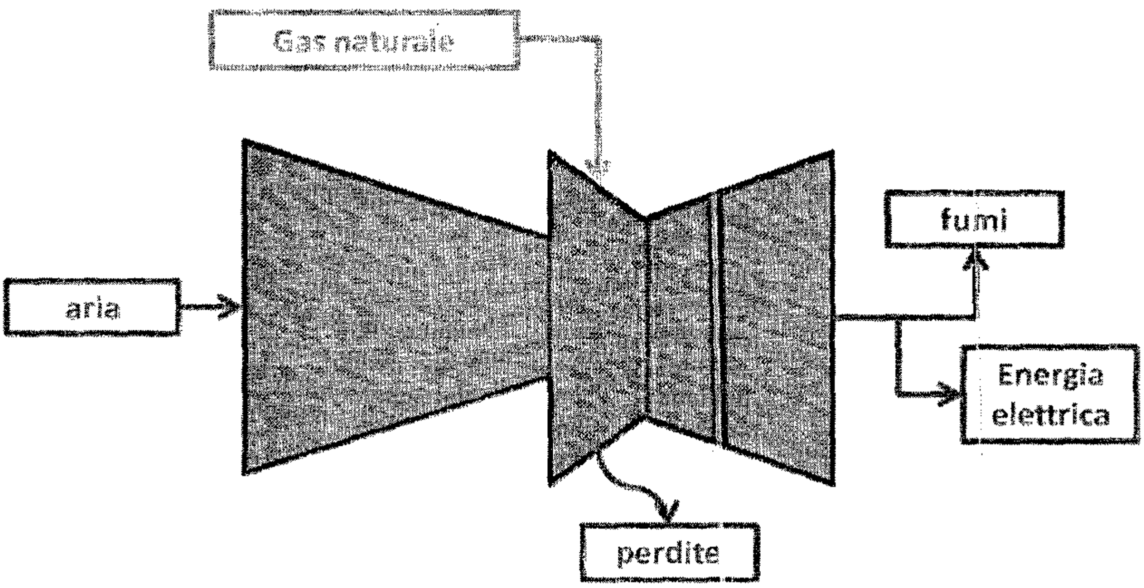
The basis for the calculation procedure is the international standard ISO-2314:1989 (E) "Gas turbines - Acceptance tests", worldwide code used for final load tests and for common evaluation of good performances of gas turbines.

3. EXHAUST GAS FLOWRATE CALCULATION

The procedure to calculate the exhaust gas flowrate shall start first from the definition of limits of "control volume"; the control volume is the restricted area where to apply the mass and heat balances.

3.1 Control volume and related parameters

The picture below shows the control volume defined by ISO-2314, in " a manner convenient for defining all quantities of heat and energy entering and leaving this control volume".



See below the list of terms used according to ISO 2314 explanations:

- m_{a1} is the mass rate of air entering the control volume in kg/s;
- m_{f4} is the mass rate of fuel entering the control volume in kg/s;
- m_{g8} is the mass rate of exhaust gases leaving the control volume in kg/s;
- m_e is the mass rate of sealing and/or extracted air leaving the control volume in kg/s;
- m_c is the mass rate of coolant flowing through the lubricant cooling system in kg/s;
- h_{a1} is the specific enthalpy of air at temperature T_{a1} entering the control volume in kJ/kg;
- h_{a0} is the specific enthalpy of air at standard reference temperature of 15°C in kJ/kg;
- h_{ae} is the specific enthalpy of air at temperature T_e leaking from the control volume in kJ/kg;
- h_{g8} is the specific enthalpy of exhaust gases at temperature T_{g8} in kJ/kg;
- h_{g0} is the specific enthalpy of exhaust gases at standard reference temperature of 15°C in kJ/kg;
- h_{f4} is the specific enthalpy of the fuel at temperature T_{f4} entering the heat source (combustion chamber) in kJ/kg;
- h_{f0} is the specific enthalpy of the fuel at standard reference temperature of 15°C in kJ/kg;
- Q_r is the radiation and convection heat losses from the control volume in kW;
- Q_m is the mechanical losses in kW, calculated from heat balance of coolant inlet and outlet (see hereinafter);
- C_{pc} is the specific heat of the coolant in kJ/kg°K;
- P_s is the shaft output in kW, calculated from heat balance around generator (see hereinafter);
- Q_{10} is the net specific energy of fuel at 15°C and constant pressure in kJ/kg (lower heating value of fuel at 15°C);
- η_{tc} is the combustion chamber efficiency, that when burning filtered natural gas is equal to 0,995;
- T_{a1} is the flow weighted average temperature in °K of air entering the control volume;
- T_{in} is the inlet temperature of the lubricant coolant in °K;
- T_{out} is the outlet temperature of the lubricant coolant in °K.

3.2 Heat and mass balance equations

Everyone knows that energy and mass can't be created or destroyed but only transformed, so that in static conditions with no accumulation inside the control volume, all inlets shall be equal to outlets, either in terms of energy and in terms of mass, so resulting in the two following equations:

heat balance equation (1)

$$m_{a1}\left(h_{a1}-h_{a0}\right)+m_{f4}Q_{l0}\eta_{tc}+m_{f4}\left(h_{f4}-h_{0}\right)=m_{g8}\left(h_{g8}-h_{g0}\right)+m_{e}\left(h_{ae}-h_{a0}\right)+Q_{r}+Q_{m}+P_{s}$$

mass balance equation (2)

$$m_{a1}+m_{f4}=m_{g8}+m_{e}$$

The terms unknown of the above equations to be calculated are air inlet mass flow rate m_{a1} and exhaust gas mass flow rate m_{g8}; all other parameters are known by direct measures or GT manufacturer's data.

3.3 Others

According to ISO-2314 the variables of major importance in equations (1) and (2) will be directly measured with on-line instrumentation, whilst the variables of minor importance not affecting the global accuracy of final result can be set as function of major parameters according to GT manufacturer's technical information.

4. INPUT DATA

The following chapters describe the content and determination of each item included in the above two balance equations.

4.1 Air inlet

$m_{a1}\left(h_{a1}-h_{a0}\right)$

- Air inlet mass flow rate m_{a1} is one of two terms unknown of equations; unit measure in kg/sec.
- Air inlet enthalpy h_{a1} is calculated from air ambient temperature and relative air humidity on the basis of enthalpy values reported in table 1 of appendix 1.
  - Air ambient temperature is measured through nr. 2 thermoresistances at inlet gas turbine filter house, signals available at DCS.
  - Air ambient relative humidity is measured through nr. 1 humidity sensor (dielectric condenser type) at inlet gas turbine filter house, signal available at DCS.
- Air reference enthalpy h_{a0} is the enthalpy value of 31,098 kJ/kg at reference conditions of 15°C and 60%.

4.2 Fuel inlet

$m_{f4}Q_{l0}\eta_{tc}+m_{f4}\left(h_{f4}-h_{0}\right)$

- Fuel inlet mass flow rate m_{f4} is one of most important parameter measured in power plant, not only because of commercial aspects, but also because of good overhaul functionality of gas turbine itself; the mass flow rate is calculated from volume flow rate multiplied by gas density; unit measure expressed in kg/sec.

- Fuel volume flow rate, expressed in m^3/sec, is measured through orifice diaphragm restriction installed on gas line to each gas turbine just before the related performance heater; the pressure drop is measured through nr. 1 pressure transmitter with high accuracy (±0,05%), signal available at DCS.
- Gas density, expressed in kg/m^3, is calculated by correcting in temperature and pressure the reference density, expressed in kg/Sm^3, coming from gaschromatograph analyzer through direct analysis of gas composition stream; temperature and pressure of gas are measured by transmitters installed in proximity of diaphragm, signals available at DCS.

- Fuel lower heating value at reference temperature of 15°C is measured by gaschromatograph analyzer with direct analysis of gas composition stream and in case converted in kJ/kg through gas density value.
- Combustion chamber efficiency η_{tc} can be assumed equal to 1,00 after DLN tuning performed by GT manufacturer and in presence of no evidence of bad combustion in exhaust gases analysis.
- Fuel inlet enthalpy h_{f4} is calculated from fuel temperature on the basis of natural gas enthalpy tables reported in table 2 of appendix 1; fuel gas temperature before GT is measured through nr. 2 thermoresistances, signals available at DCS.
- Fuel reference enthalpy h_0 is the enthalpy value of 30,684 kJ/kg at reference conditions of 15°C.

4.3 Exhaust gas outlet

$$m_{g8}\left(h_{g8} - h_{g0}\right)$$

- Exhaust gas mass flow rate m_{g8} is one of two terms unkonw of equations; unit measure in kg/sec.
- Exhaust gas enthalpy h_{g8} is calculated from exhaust gas average temperature on the basis of enthalpy tables reported in table 3 of appendix 1; exhaust gas average temperature is average value calculated by MARK VI and measured by nr. 33 thermocouples at gas turbine outlet, all signals available at DCS.
- Exhaust gas enthalpy h_{g0} is the enthalpy value of 15,630 kJ/kg at reference conditions of 15°C and 60% rh.

4.4 Shaft power output

$$P_s = P_e + Q_e$$

- Shaft power output P_s is net mechanical shaft power transmitted to electrical generator for conversion to electrical power; it can be calculated from electrical power measure back through efficiency values of generator.

- Electrical power P_e is measured at generator limits by electrical instrument devices of voltage, current and cosϕ; accuracy class of CT's and VT's is 0,2.
- Generator overhaul losses Q_e are calculated on the basis of manufacturer's efficiency curves. A typical curve is shown in appendix 2; as the oil lubrication system is common to gas turbine and generator, the value of heat losses coming from generator gears will be deducted from mechanical losses global value Q_m.
- Net shaft power so results as the sum of electrical power and generator losses.

4.5 Mechanical losses

$$Q_m = m_c c_{pc}(T_{out} - T_{in}) + Q_f - Q_{me}$$

- Mechanical losses Q_m are all transformed in heat losses to the oil lubrication and coolant system, so they can be calculated from measures on oil parameters.
  - m_c is the oil mass flow rate value pumped during normal operation by oil pump; it's a constant value of about 65 kg/sec;
  - c_{pc} is the specific heat of oil and can be assumed as a costant value of about 2 kJ/kgK.
  - T_{out} is the average oil outlet temperature back to oil recovery tank after passage through gas turbine gears; it is measured through nr. 1 thermoresistance, signal available at DCS.
  - T_{in} is the average oil inlet temperature to gas turbine gears, measured downstream the oil coolers; it is measured through nr. 1 thermoresistance, signal available at DCS.
  - Q_f are the heat losses resulting by oil exhaust demister to environment; based on manufacturer's data this increases losses by 1%.
  - Q_{me} are the generator mechanical losses that shall be deducted from global mechanical losses as already counted in generator losses; the value can be expressed as 30% of global mechanical losses based on manufacturer's data at nominal load.

4.6 Cabinet air cooling losses

$$m_e(h_{ae} - h_{a0})$$

- Cabinet air cooling losses are assumed equal to zero, as no compressed air is extracted from gas turbine compressor and no use of air as sealing barrier is made inside gas turbine; the air cooling pumped through fans to keep the cabinet internal temperature at proper value for equipment and personnel is evaluated in the following heat radiation & convection losses.

4.7 Heat radiation & convection losses

$$Q_r = \sum_{i=1}^{n} m_i(h_{out} - h_{hall})$$

- All the heat losses produced by radiation & heat convection of gas turbine hot-surfaces are counted referring to the air cooling pumped through fans; during normal operation at base load nr. 4 fans are in service, pumping about 200.000 m^3/h, equal to 70.000 kg/sec.
- The enthalpy of inlet air cooling is calculated from machine hall air ambient temperature on the basis of enthalpy tables reported in table 1 of appendix 1.
- The enthalpy of outlet air cooling is calculated from cabinet air internal temperature on the basis of enthalpy tables reported in table 1 of appendix 1.

4.8 Minor losses

Minor losses are all heat losses not foreseen in above chapters and related to special events of gas turbine operation, such as air leaking from air compressor bleed heating line, exhaust gases leaking from boiler, etc … are not considered in calculation.
In future if there will be structural evidence of them, even if negligible they will be counted in.

5. CALCULATION ACCURACY

Global accuracy depends upon the accuracy of each term, but mainly we can state that it depends by a correct evaluation of the following two items:

- Shaft net power output
- Fuel gas inlet

In fact air inlet and exhaust outlet evaluation is made through measures of inlet and outlet temperatures, with 0,1°C level of accuracy, on which basis enthalpy tables provide the values; humidity air content is also considered in enthalpy air inlet correction; note that 0,1°C mistake means less than 0,2‰.
All other terms of equation have minor or negligible importance, so that their level of accuracy (low or high) has no impact on final results.
Coming back to the above two terms, we can state the following accuracies on main parameters:

- 0,25% accuracy for electrical power of generator;
- 0,5% accuracy for fuel gas mass flow rate.

No mention has been made to fuel gas chemical composition as it was considered constant and equal to the reference one reported in EPC contract; fuel gas and exhaust gases enthalpy tables have been calculated on this hypothesis and in future they shall be re-adjusted to measured value of natural gas composition.

6. IMPLEMENTATION IN DCS

Calculation of exhaust gas mass flow rate is made by DCS instantaneously based on all above listed terms on the basis of enthalpy tables reported in appendix 1 and generator efficiency curves reported in appendix 2.

7. FINAL CONSIDERATIONS

The exhaust gas mass flowrate has been evaluated by heat and mass balances around gas turbine control volume, as this method is the most accurate among the available ones; other methods are listed hereinafter.

7.1 *Indirect methods*

Other indirect methods are the following:

- heat and mass balances around boiler control volume, as reported in ASME code for boiler performance evaluation; this method, even similar to the selected one, is complex the same but less accurate because of big impact of high number of steam and water mass flow rates measured through orifice diaphragms;
- chemical combustion balance; through the measure of oxygen content in exhaust gases and the known composition of fuel gas, i.e. carbon content, the air/fuel ratio can be calculated; this method is complex the same or more, with a lot of calculations to be implemented in DCS, requiring the best accuracy and reliability in oxygen direct measure at stack outlet, resulting at the end less accurate than above;
- inlet guide vane (IGV) position; based on manufacturer's curves and direct measure of first air-compressor movable blades, signal available at DCS, it is possible to evaluate inlet air mass flow rate; the sum of air flow and fuel flow results in exhaust one.

7.2 *Direct methods*

Direct methods to measure exhaust mass flow rate are the following:

- ultrasonic measure;
- pitot-tubes measure;
- orifice diaphragm measure (only for small stack diameter).

The benefit of direct measure is mainly that none of terms used for calculation may affect the measure, so resulting in overhaul better reliability and during plant transients also in better evaluation of mass flow rate.

The disadvantage of direct measure is that on large stack diameter as Termoli ones(6,3 mt), the accuracy of direct measure is below the accuracy of indirect methods, even when the measure is performed through ultrasonic devices.

- APPENDIX 1 -

AIR ENTHALPY TABLES

Air ambient humidity rh% in x-axis - Air ambient temperature in y-axis

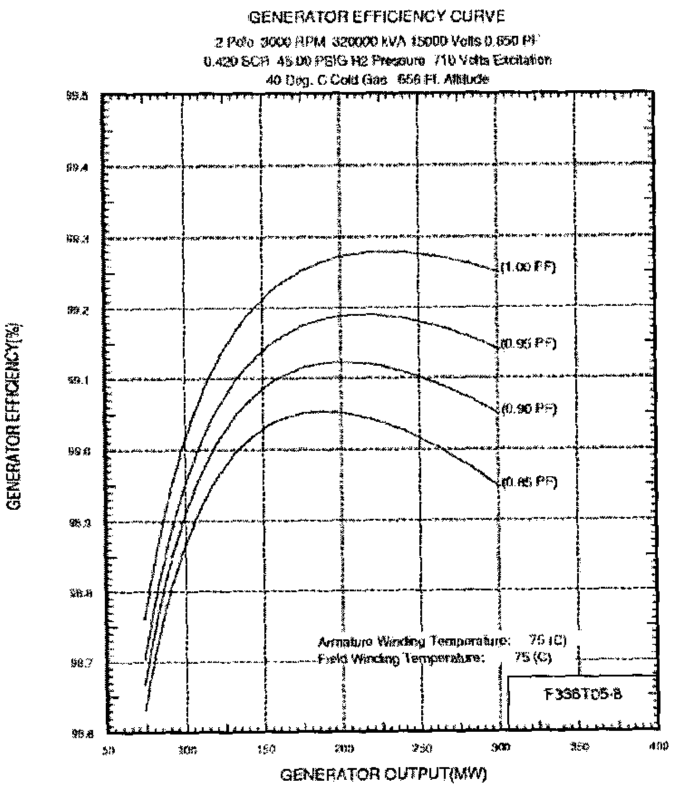
	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
-10	-9,655	-9,259	-8,863	-8,467	-8,071	-7,674	-7,277	-6,880	-6,483	-6,086
-5	-4,414	-3,802	-3,190	-2,577	-1,964	-1,350	-0,736	-0,121	0,494	1,109
0	0,937	1,875	2,814	3,755	4,696	5,639	6,582	7,527	8,473	9,421
5	6,368	7,713	9,061	10,411	11,764	13,118	14,475	15,835	17,197	18,561
10	11,948	13,851	15,759	17,671	19,588	21,510	23,436	25,367	27,303	29,244
15	17,723	20,380	23,046	25,721	28,405	31,098	33,801	36,512	39,233	41,963
20	23,748	27,413	31,095	34,794	38,510	42,244	45,995	49,763	53,550	57,354
25	30,091	35,089	40,118	45,179	50,273	55,398	60,557	65,748	70,973	76,231
30	36,837	43,580	50,381	57,239	64,156	71,133	78,169	85,267	92,426	99,648
35	44,085	53,094	62,205	71,420	80,739	90,166	99,702	109,348	119,107	128,980
40	51,955	63,883	75,989	88,276	100,749	113,411	126,268	139,324	152,583	166,050

FUEL GAS ENTHALPY TABLES

Fuel gas enthalpy in kJ/kg related to fuel gas temperature to GT burners

	temp.	Enthalpy	temp.	Enthalpy	temp.	Enthalpy	temp.	Enthalpy	temp.	Enthalpy
	0	0,000	50	104,327	100	215,470	150	334,642	200	462,435
	10	20,403	60	125,961	110	238,635	160	359,501	210	489,048
	20	41,021	70	147,882	120	262,130	170	384,708		
	30	61,870	80	170,101	130	285,960	180	410,265	15	30,684
	40	82,968	90	192,627	140	310,130	190	436,174		

APPENDIX 2



Prepared by NG