WEMES Consulting srl
Consulenze e Servizi per l'Ingegneria - Wide Electrical and Mechanical for Engineering Service
Via Rossini, 31/a I-30171 Mestre (VE) - ITALY
E-mail: wemes@wemes.it WEB: http://www.wemes.it

Tot. Pag. :
Date: 10/10/2011

to : Industrial Steelmaking Plants

Att.n : (Technical Office)

Telephone :
Telefax :
Mob. :
Email:

from: Dr. Alberto Fragiacomo
E-mail: alberto.fragiacomo@wemes.it
Tel. : +39 041 8020015
FaxToEmail: +39 02 30132890
Mob.: +39 347 2618940

Your ref.:

Our ref.: O11_14a

Subject:
• Detection System and Operations Control for the metallurgical furnace AC-EAF
• Monitoring and managing energy saving, lines EAF Furnaces / LF / Services and Rolling Mill

Object:
• Measurement, Analysis, Study for the design of the control system for the inclusion of lime and CARBON in the AC-EAF Furnace. (Custom measurements are possible)
• Conducting and monitoring energy consumption in real time with the timing of loading baskets and refining, supply, installation with installation, commissioning.
• Hardware and software platforms will be as follows:
PLC control (type Vipa)
HMI interface or display, (Type Vipa or NI)
DIRIS N 300/600 SOCOMEC
Compact RIO-the National Instruments LabVIEW, FPGA, Real-Time
Dedicated software for Custom Measurement / Monitoring / Analysis

Message: How requested, we are pleased to submit our offer for the study in question, for variations on the design of measures to control the AC-EAF furnace in your production plant.

Remaining at your disposal for any clarification
We take this opportunity to extend best regards

WEMES Consulting
Dr. Alberto Fragiacomo

Ns. rif.: O11_14a **Mestre, 3 October 2011**

1. Job object.

• Measurements of voltage, harmonics, load active and reactive and related analysis. (Line with EAF furnace).

2. Scope of job.

- The intervention is designed to verify and measure the reactive power and harmonics current absorption of the furnace EAF, and on MT busbar.

• Analysis of measurements made earlier and check of the operation the filter power factor correction.
• The study analysis was designed to test: the active and reactive power, power factor, high voltage, output harmonic current, voltage variation and harmonic distortion of the bar of the furnaces of medium voltage and high voltage line POWER SUPPLIER.

3. Supply description.

Principal measures to be taken:

• Measurement of three-phase active power, reactive, apparent.
• Harmonic Spectrum, harmonic distortion, voltage and current (IEC 1000-4-7).
• waveforms and three-phase rms voltage and current.
• Measurement of phase unbalance current and power.
• Measurement and Statistics on the current supply and filtered capacitors.

The elaboration of the measures focus mainly on:

• Development, analysis, drafting of the report on the measures carried out and described above.
• Analysis of the operation of power factor correction.
• Overall assessment of findings and possible measures to be taken.
• Check the operation of the plant as a whole today.

Table # Description Measurements activities

Measures V, I, P, Q, THDV, THDI, harmonics and Interharmonics to the line of HV/MV AC-EAF furnace from Power transformer and Step-down transformer. At least 30 duty cycle (heats) or 48h
Three-phase operation up to max power and a basket with two-phase operation and without power factor correction filtered and SVC. Connection point in HV and MV
At least 30 duty cycle heats or 48 h, Normal Operation, Connection Point MV
Harmonic impedance measurement of the HV electrical network at the beginning and the end of the tests.
Real-time measurement of the impedance at 50Hz of the HV or MV depending on the connection point
Measurement of the dipole power supply network, using the methods, insertion or disconnection of an inductive/capacitive load, through the direct measurement with the equipment owned by us, by insertion of the step-down transformer.
Given the characteristics of the instrument CA8253, this allows the measurement of the spectrum with a resolution of at least 1 Hz, in transient mode. This makes it possible to set the trigger on a specific harmonic. So, being the Furnace AC or DC converter, a non-linear dissipative powered externally imposed frequency, when operating in a state of chaos (always) which can be amplified by the drive control, this means that the sub-harmonic are of low magnitude, and in any case be confused with the modulation, also the density of the power spectrum for the part which we call interharmonic level will be lower than the 'worst case' due to the harmonic (impulsive) harmonic frequency. In the worst case, however, the trend of the Interharmonics will be inverse exponential with exponent not exceeding that determined by the envelope of the worst-case harmonics. That said we believe the instrument is sufficient to detect the Interharmonics (or frequency spectrum) for the designs or projects you require.

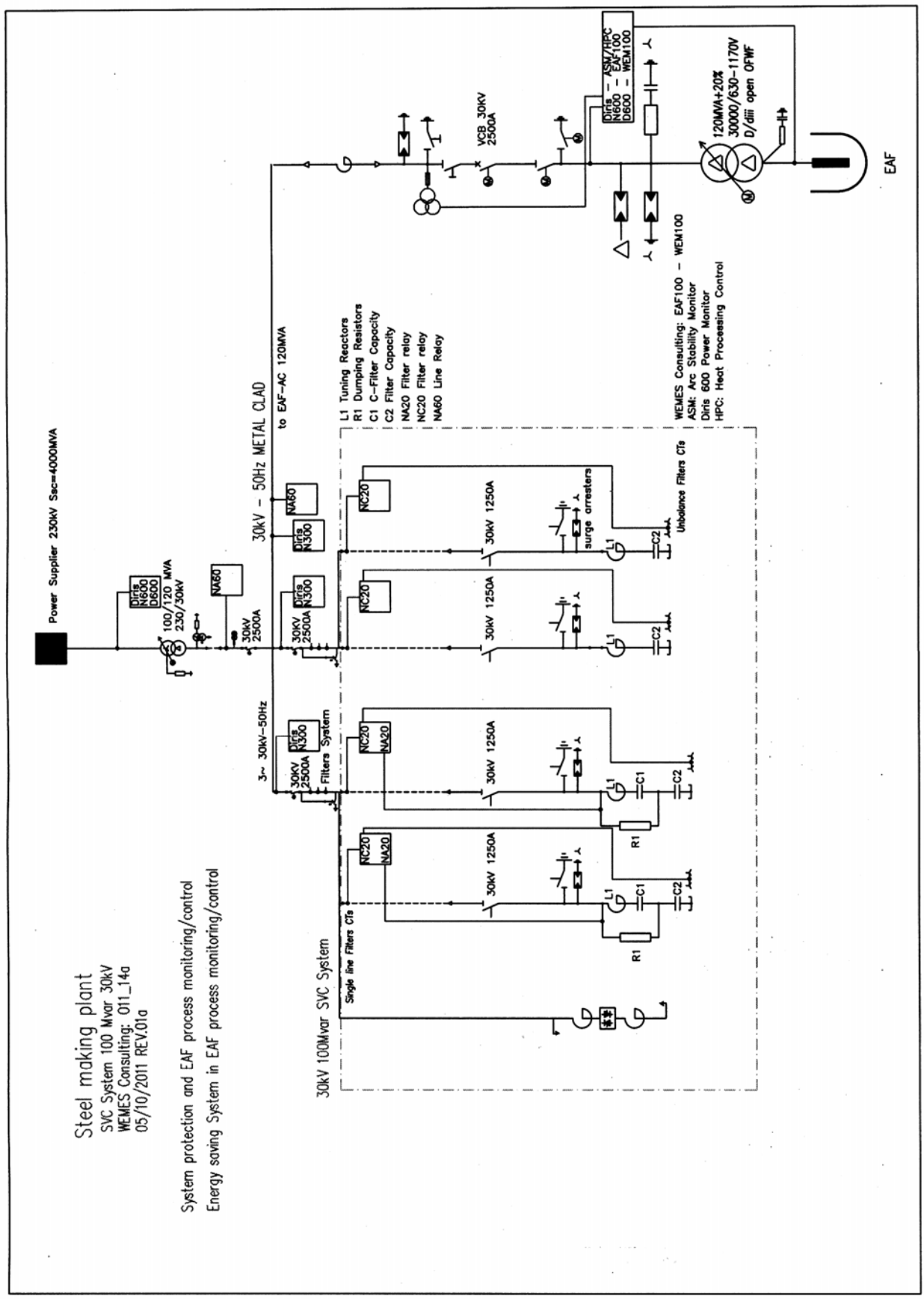
1. Instrumentations used;
1. Chauvin Arnoux CA8253 advanced network analyzer also used to ITALIAN POWER SUPPLIERS, IEC 61000-4-30, IEC 61000-3-6, IEC 61000-4-7, see accompanying manual
2. Circuitor AR5 network analyzer (reserve)

2. The instruments are connected as shown in single line diagram
1. Step Down Transformer for both the AT and MT, which is closely dependent on the measurement made, even on the line MT-AC EAF

3. Measurements taken for each connection point (the precise description with temporal sampling, will be recorded at each sampling);
1. the measures to be carried out are those with the procedures indicated in the custom table
2. Furthermore, all measures necessary in our opinion.
3. mininun sampling times are those of the IEC.

4. As for the design work project we will use the following design programs;
1. DIGSILENT and / or NEPLAN, PSPICE
2. Proprietary software developed ad hoc, and / or analytical calculations and automation, C C# FORTRAN
3. AUTOCAD, PLC STEP7 or WINPLC7

	Items
1	Measures and preliminary analysis in plant
2	Supply Engineering for a system of monitoring / process control and general supervision of the post-AC EAF furnace in MV / LV to be entered into the general management of the heating process automation in the Furnace Cabin with protections for the measuring points and control MV <36kV and LV<1kV
3	WEMES Consulting: ASM/HPC (Arc Stability Monitor / Heat Process Control) + DIRIS with Stability System for the Detection of harmonics for arc furnace AC-EAF: parameterization and construction for the DP (arc stability detect) active power, reactive power DQ and current DI; THDI and Ih (harmonic order n)
4	AMS/HPC, EAF100, WEM100, PLC-VIPA313c
5	DIRIS: N600, N300, D600, O600
6	Supervision HMI and PLC Control Software (Custom)
7	Commissioning Technicial, Installation, testing and final measures, final reports


Power Supplier 230kV Ssc=4000MVA
100/120 MVA 230/30kV
Dirls N600 D600
NA60
30kV 2500A
30kV - 50Hz METAL CLAD
to EAF-AC 120MVA
NA60
Dirls N300
30kV 2500A
3~ 30kV-50Hz
Filters System
30kV 100Mvar SVC System
Single line Filters CTs
NC20
NA20
30kV 1250A
surge arresters
L1
C1
C2
R1
Unbalance Filters CTs
L1 Tuning Reactors
R1 Dumping Resistors
C1 C-Filter Capacity
C2 Filter Capacity
NA20 Filter relay
NC20 Filter relay
NA60 Line Relay
WEMES Consulting: EAF100 - WEM100
ASM: Arc Stability Monitor
Dirls 600 Power Monitor
HPC: Heat Processing Control
VCB 30kV 2500A
Dirls - ASM/HPC
N600 = EAF100
D600 = WEM100
120MVA+20%
30000/630-1170V
D/diii open OFWF
EAF
Steel making plant
SVC System 100 Mvar 30kV
WEMES Consulting: 011_14a
05/10/2011 REV.01a
System protection and EAF process monitoring/control
Energy saving System in EAF process monitoring/control

1. Job object.

Parameterization and construction of a custom device to be inserted on the regulation of AC furnaces (EAF). The regulation is supported in tension, power and impedance: TDR-Techint/Tenova, Danieli, Fuchs, VAI-Siemens, SMS-Demag.

2. Scope of job.

Detect the state of the arc and its stability of operation in the EAF/LF Furnaces.
Correct the variation of the working point of the furnace EAF/LF, when the supply voltage decreases due to load fluctuation (variation of arc, etc..).

3. Supply description.

- Preliminary measurements on the EAF/LF furnaces to compensate,
- Short circuit proof, for EAF/LF furnaces
- Analysis, simulation and calculation of optimal operating points to be included in the electrodes regulation
- Calculation of short circuit power for each of the TAP Trafo EAF/LF furances,
- Parameterization of the components of the compensator and its ad hoc custom construction,
- Listing and commissioning with verifying the correct operation

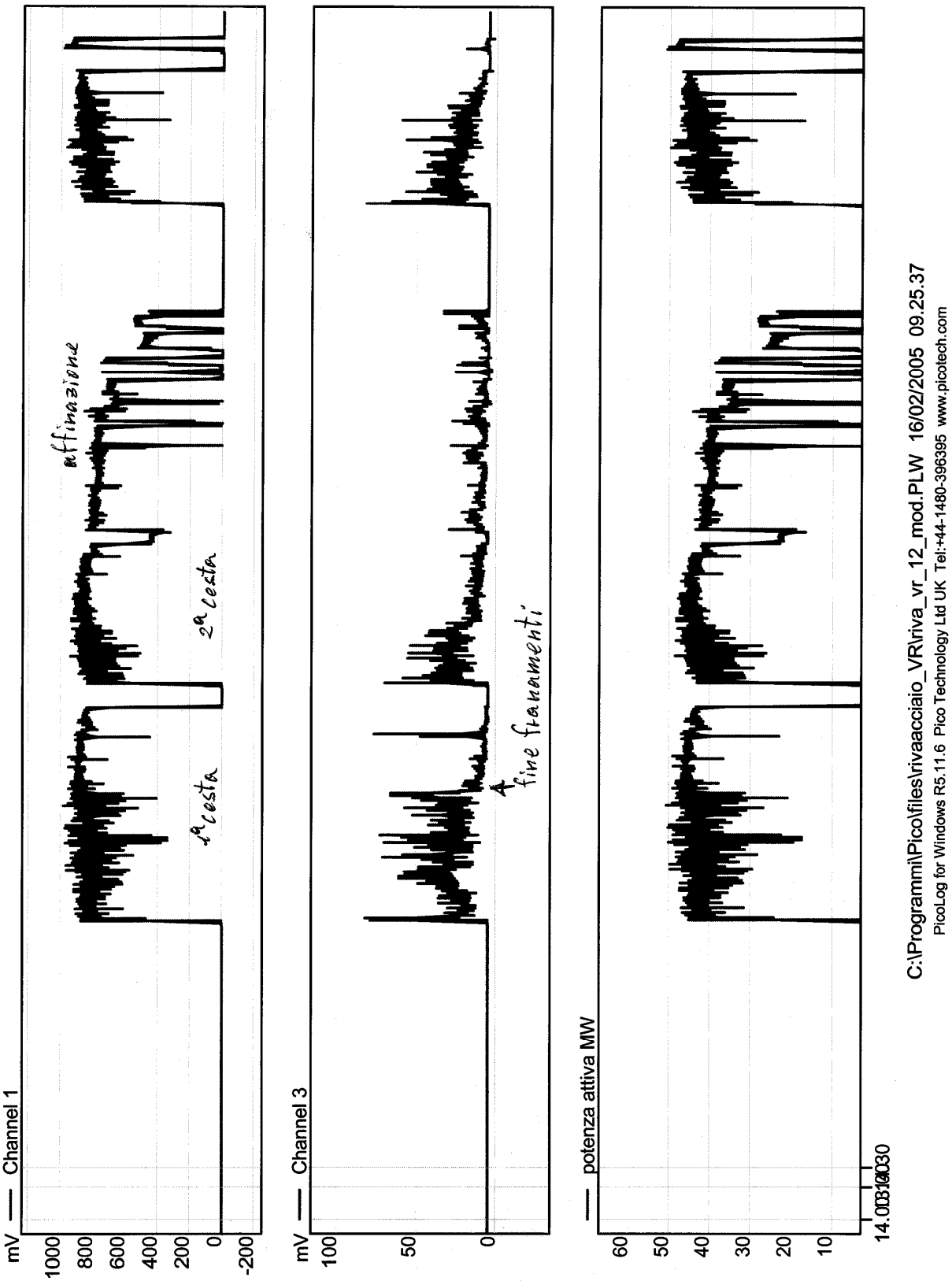
- **For the detector of Arc Stability:**
- Parameterization of the components of the detector and its ad hoc custom construction,
- Final Measurements at the furnace compesated.
- Supply of equipment, drawings and design, commissioning with testing
- Supply of material with installation and commissioning services for the EAF compensator/stability detector.
- providing supervision system positioned in the EAF/LF pulpit cabin

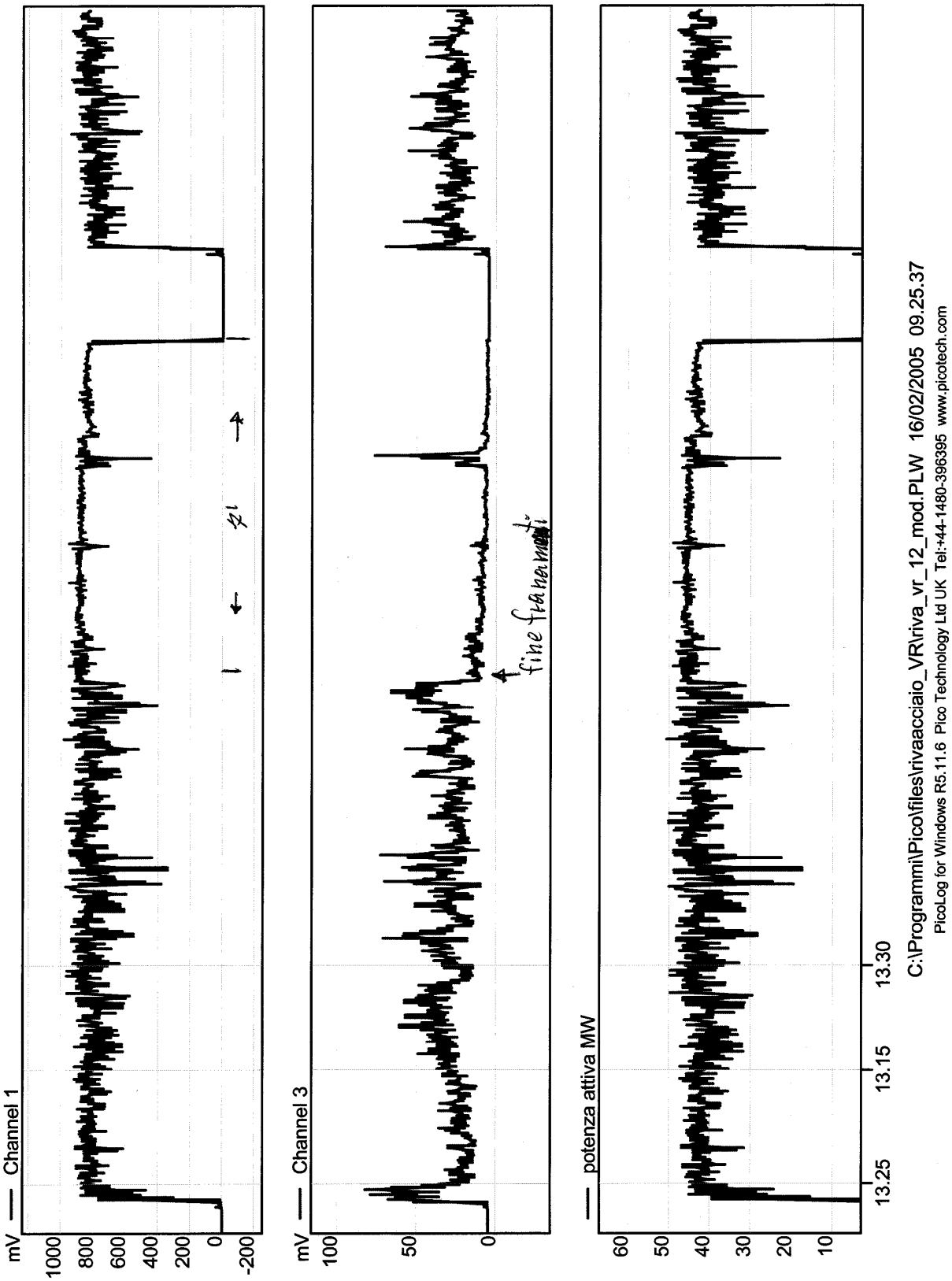
Preliminary data to find: (see attached questionnaire)
1. Single-line diagram of system and network connection POWER SUPPLIER
2. Data of the EAF/LF furnaces (tonnage, impedance, etc..).
3. Typical heat report of the EAF/LF (P, Q, I, Varc, power factor, time, C, O2, etc..).
4. Data of Electrical machines EAF/LF
5. Type of electrodes regulation EAF/LF furnaces, its operation, electrical characteristics and performance, input and output parameters of measurement and control electrodes.
To facilitate the retrieval of data are attached our standard questionnaires, as the general trace.

Results of recent installations in service
The above results were obtained by inserting the "DVcomp.", And changing the current set-point controller pads as indicated above.
The analysis of the recordings it is clear that after the insertion of DVcomp. all sizes have reduced their fluctuations favoring the transfer of power from the arc to melt.
From the parameterization of two baskets heats, the first day without the "DVcomp.", The second day with the "DVcomp." Plugged in, the preliminary results as follows:
The energy consumption was reduced on average by heat 400kWh/ton less than 380kWh/ton.
Power ON time has been reduced on average by more than 55min to less than 50min.

To further improve the power savings achieved in the management of the furnace EAF, once inserted a compensation voltage, calculate the current and arc voltage to optimize: the radiation and the best power transfer arc to melt scrap/DRI, should be supplemented by monitoring the process of merging with a detector of changes in active-reactive powers DP-DQ and DI of the three currents of the electrodes, all controlled by software and a PLC with a weighting function. Indicates the PLC output when changing the tap-changer, the set-point of the "control electrode" in advance and ready to load a new basket and/or the beginning of the overheating refining (for the foamy slag, deslagging, etc..).

Others results were obtained by inserting the "DVcomp.", And changing the current set-point regulator electrode as indicated above.
The analysis of the recordings it is clear that after the insertion of DVcomp. all sizes have reduced their fluctuations favoring the transfer of power from the arc to melt.
From the parameterization of two-cast baskets of two periods, the first day without the "DVcomp.", The second day with the "DVcomp." And added the new points of work, preliminary results as follows:
Power is increased by about 46MW 53MW average to about average with the balance of the voltage transformer substation, also introducing a new operating point Ua and Ia 550Vdc 105kAdc can exceed 56MW average.
The energy consumption was reduced on average by casting 380kW/ta less than 340kWh / t.
Power ON time has been reduced on average by more than 40 minutes to less than 36min.


Channel 1
mV
1000
800
600
400
200
0
-200
affinazione
1ª cesta
2ª cesta
Channel 3
mV
100
50
0
fine fiamenti
potenza attiva MW
60
50
40
30
20
10
C:\Programmi\Pico\files\rivaacciaio_VR\riva_vr_12_mod.PLW 16/02/2005 09.25.37
PicoLog for Windows R5.11.6 Pico Technology Ltd UK Tel:+44-1480-396395 www.picotech.com


mV
Channel 1
1000
800
600
400
200
0
-200
Channel 3
100
50
0
potenza attiva MW
60
50
40
30
20
10
13.25
13.15
13.30
C:\Programmi\Pico\files\rivaacciaio_VR\riva_vr_12_mod.PLW 16/02/2005 09.25.37
PicoLog for Windows R5.11.6 Pico Technology Ltd UK Tel:+44-1480-396395 www.picotech.com

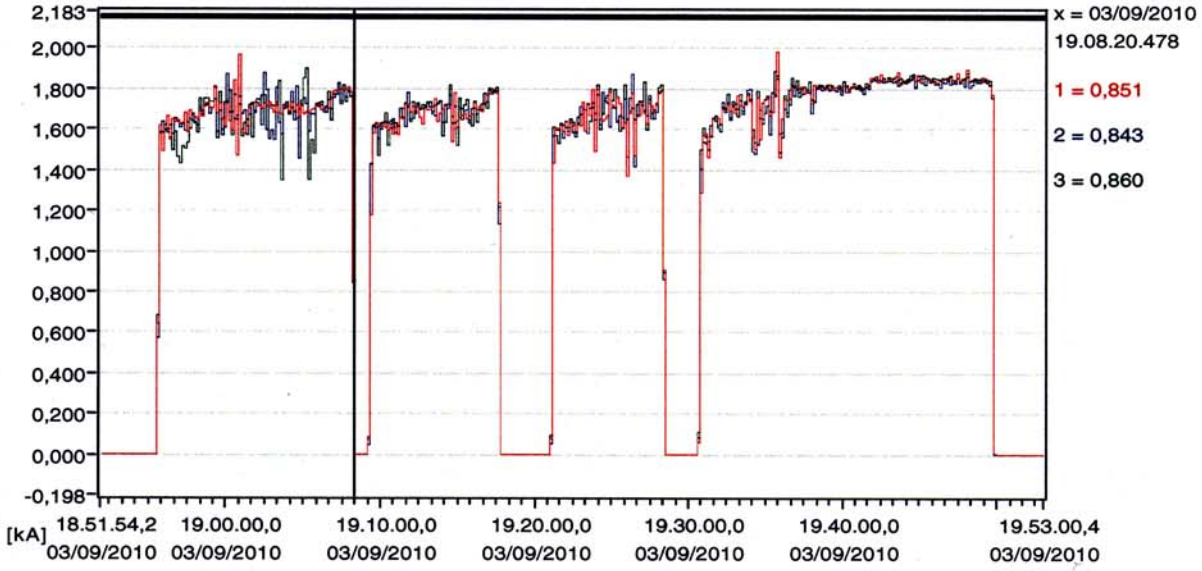
WEMES C

Protocollo graf. X(t)

	1. graf.	2. graf.
Luogo di misura:	forno EAF tdr-prot-mis	forno EAF tdr-prot-mis
Nome utilizzatore:		
Strumento:	V: 2.4.4 20.11.2007, Lic.: 39080230	V: 2.4.4 20.11.2007, Lic.: 39080230
Descrizione:	rif mt 22.9kv	rif mt 22.9kv
Intervallo di registrazione:	3sec	3sec
Inizio misure:	03/09/2010 9.23.09	03/09/2010 9.23.09
Arresto misure:	04/09/2010 9.43.42	04/09/2010 9.43.42
Tensione di riferimento	30,00 kV	30,00 kV

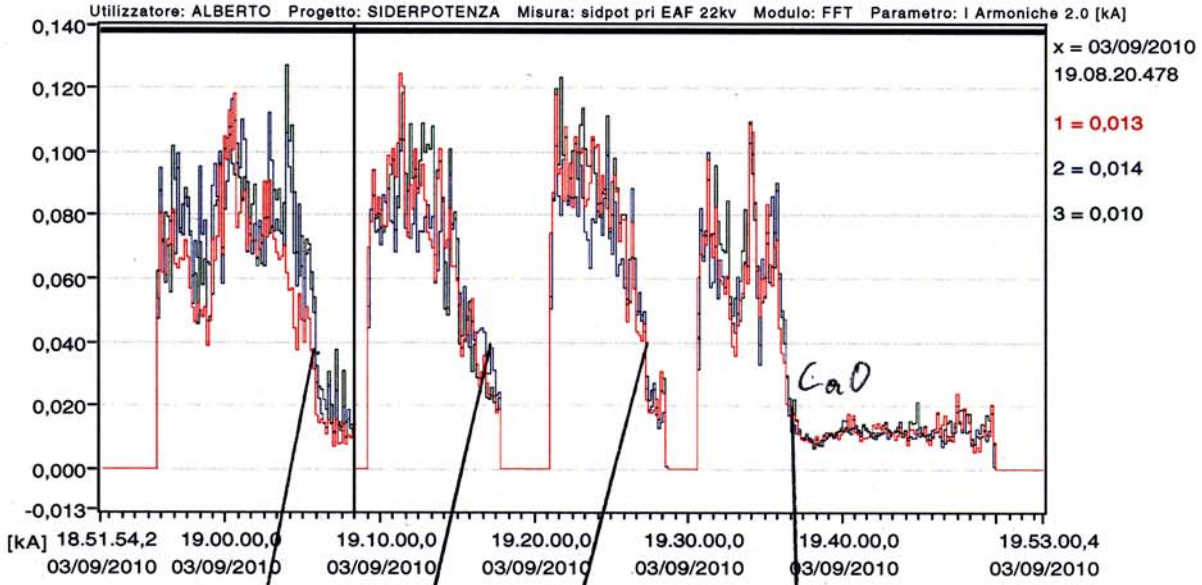
I Armoniche 1.0 [kA]

Utilizzatore: ALBERTO Progetto: SIDERPOTENZA Misura: sidpot pri EAF 22kv Modulo: FFT Parametro: I Armoniche 1.0 [kA]



I Armoniche 2.0 [kA]

Utilizzatore: ALBERTO Progetto: SIDERPOTENZA Misura: sidpot pri EAF 22kv Modulo: FFT Parametro: I Armoniche 2.0 [kA]



C C C

Data: Firma:

Lime blow (CaO)
Start Refining

[redacted]

Carbon blow and Basket charge

Supervision System EAF-AC/DC furnaces with Monitoring on powers, voltages, currents and harmonic on busbar "High Voltage" or "Medium Voltage"

If the results of calculations and simulations reveal that for low short-circuit power of Node Power System or strong reduction of the voltage of the network does not reach the desired arc power in the furnace, can be added externally to the furnace electrodes regulator a complex static with a continuous function influences the set-point, optimizing control of the power of the furnace in the field of ± 10% of variation in voltage.
By filling out worksheets at different voltage, you can find the compensation rate (dV% Comp), optimal for DV corrector setup to introduce externally at electrodes regulator to optimize the power of the arcs.

Monitoring of the process of fusion
By monitoring the power arc, was put in place a relay-regulator which continuously indicate the better working condition of the arcs and give the 'OK' to change the tap-changer or set-point "control electrode".

Appendix 1
This method of work, (computer simulation is non-linear trends that govern the arches), lets you know with a maximum error of ± 2%, the different parameters involved in the working point calculated, you can also tell if the point chosen is valid, if it is unstable arc zone and if any unborder from the largest electric plant capability.
The consulting can be very flexible, does not necessarily require the intervention on the system, can be brought only with the exchange of email or fax, (of course a measurement session is recommended), or data exchange with the visit of one of our technicians.
Any measurements can be made at the end of the intervention, to confirm the accuracy of the points introduced in the choices and electrodes control.
The registration of some melting profiles, (at least 20-30 heats), can be done with three-phase digital recorder, with data acquisition at intervals of 0.2-1 second, to: Vrms, Irms, P, Q, THD, Flicker. (the records are transferred for statistical data processing in Excel or others programs).
For the processing time of working points, boring, refining and refining-casting will be around 10 days, (depending on how much data, the parameters of the system, you already have on file and you want to have as many elaborations).

Benefits of the intervention: (from measurements on furnaces already in operation)
Electricity Energy savings achieved in operating a direct-type arc furnace EAF, by inserting a compensation voltage, and calculating the current and arc voltage to optimize: the radiation index and the best power transfer arc-melted to scrap or DRI, reducted electrodes consumption and refractary lining.

Stability Detector of the arcs, furnaces EAF-AC/DC

Part 1) Characteristics of AC-DC arcs.
Part 2) New Method arcs monitoring.
Part 3) Installation equipment.
Part 4) Configuration of the DP-relay for the of stable arcs detection.

Part 1 Characteristics of the arcs

The arcs are made of a conducting tube-plasma starting from graphite electrodes initially comes to the scrap to melt, then to melting bath.
Their length, depending on working conditions and the type of furnace, EAF or LF, can vary from 400 mm to 500 mm (EAF) or 60 to 100mm (LF)
The waveform of the voltage as a function of the current is almost square, and assumes even with low values of current (a few hundred amperes), the voltage Vn of arc, with the value determined almost exclusively by its length by the following expression:
Vout [Vrms] = 40 + length [mm]
The arcs current, depending on the type of furnace and the working point, can vary from 20 to 75 kA for AC furnaces, and can reach 120 kA for DC furnaces.
For AC furnaces, the continuity of current at the point where the tension is insufficient, it has the effect of the continuity due reactance of the circuit, including electrical network, which currently continues to provide energy to the arcs themselves.
For this reason it is not possible to take a Q / P ratio to the furnace of less than 0,698.
tg-fi = Q / P < 0,698, (power factor> 0.82)
It 'must remember that due to the almost square waveform of the arc voltage, the power is given almost exactly at the arc from the rms value of the arc voltage, (which also coincides with its average value), multiplied by the average value of the arc current, the circuit losses are given by, 3*R * I² rms, from what we see that the losses are growing faster by a factor of the increasing power of the arcs.
The arcs as they are, working in conditions of latent instability status, better manage the skills but also knowledge of the exact point of work related to the characteristics of the plant.
The instability is greatest during boring and first-melting time, at the beginning of each basket, due to the continuing instability of the arc jump on the scrap cavity.
A few minutes after the start of boring, which has melted few scrap under each electrode, the arcs trend is almost to stabilize, but the effect of the mutual electrodynamic actions each arc still trends to find the bath with paths describing the frequency of scanning variables between 2.0 and 6.0 Hz depending on the length of the arcs and the mechanical size of the furnace.
The stabilizing action on the arcs is later in time when you can inflate Carbon and Lime to the foaming slag at this point they are harnessed in the channels that were formed in the slag and stop floating.
Knowing the various steps of work when the furnace and the foaming slag is efficient, allows you to make the most of the time most appropriate to vary the tap-changer and the set-point arc length.

Part 2) monitoring arcs Criterion.

As mentioned, the three arcs of the furnace are subject to the following causes of non-linearity, that under certain conditions and periods lead to a chaotic, dispersive operation:

-Ask for a nominal voltage at the beginning of the current period.

Consequently, the wave-shaped voltage is almost square.

-Because of their mobility, the arches vary their length: first, for the conditions of the underlying state of the scrap-DRI, according to the mutual action between them electrodynamics forces, (frequency of variation between 0.2 and 45 Hz, depending on size of the EAF furnace and the arc length).

-Consequently there is a variation of the non-linear resistance of the arc along the electrical semi-period 10ms and at variable from period to period of the supply voltage.

For these reasons, it is essential to have a device that defines the different working conditions of the arcs, thus helping the electrodes and heat control of the furnace, or better interacting in the PLC during the various phases of the heating process.

Later learning and Experience , working conditions of the arcs can be defined by measuring the first and second derivative of the weighted power variation with frequency.

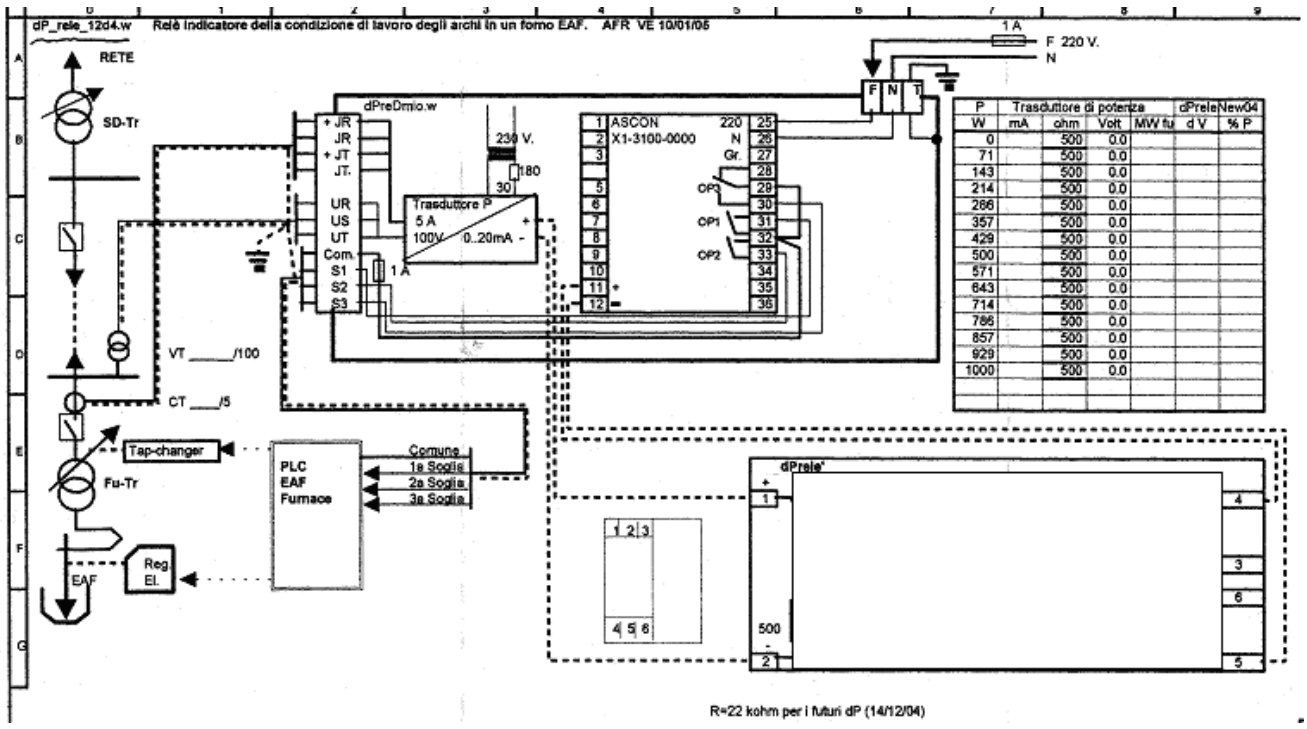
Diagram in the table below, are suitable for different conditions of the arc fluctuations δP*Hz, which correspond to as many states work.

State Working State	Zone arc fluctuation of P (%)	(%) δ P / Pn	
I = unstable Arcs	δP *Hz-arc / Pn	> 30%	unstable arcs Zone
P = perturbed Arcs	δP *Hz-arc / Pn	15 ÷ 30%	disturbed arcs
T = quiet Arcs	δP *Hz-arc / Pn	<12%	quiet arcs
C = stable Arcs	δP *Hz-arc / Pn	<7%	stable arcs Zone

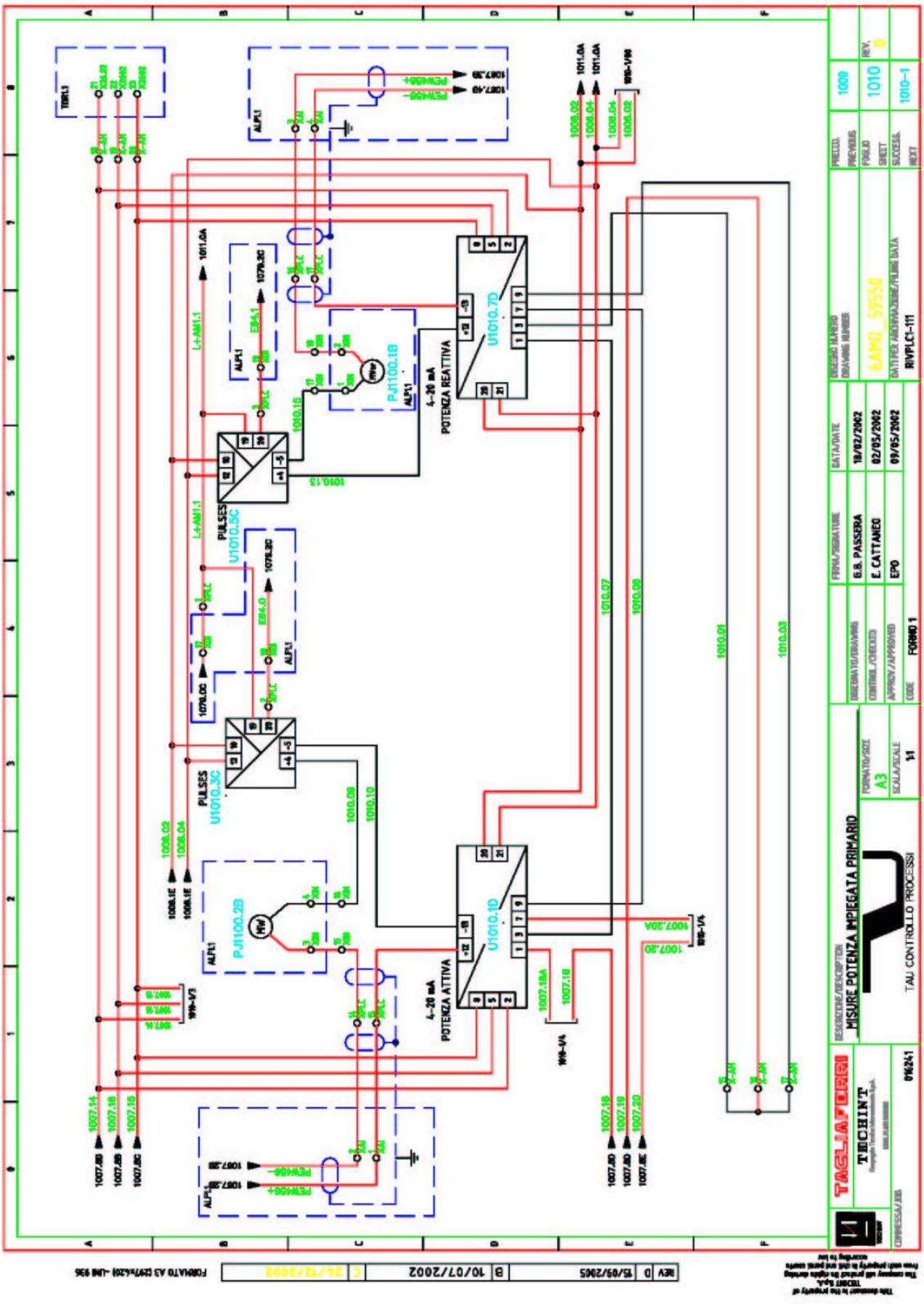
Annex 1 - Equipment and installation (SAMPLE).

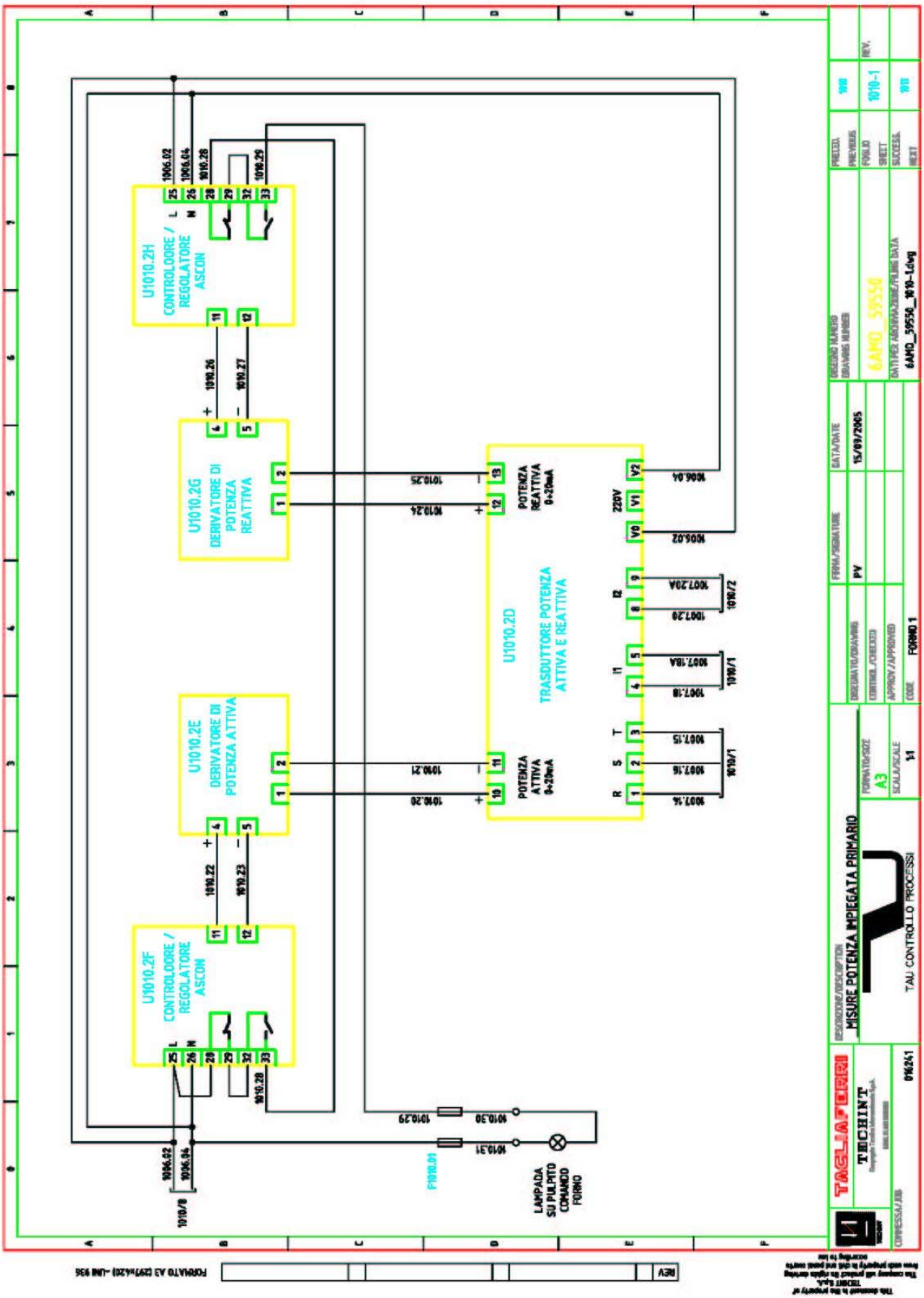
Below is outlined the insertion of the DP-DQ relay, indicator thresholds arc of instability.
For connections to the power transducer and to the PLC of the supervising furnace EAF control, use shielded cables, with screen earthed at one end only.
Put on the power of DP-DQ relay circuit breaker, observe that the phase goes to terminal No. 25 and No. 26 wire to the terminal.
DP 0205 01/21/2005 DP (f) = 5Hz
Power threshold 0.03V
With DP = 0.25V DVout 9mV
With DP = 23mV 0.50V DVout

Wiring diagram of the relay dPrele '



P W	Trasduttore di potenza mA	ohm	Volt	MW fu	dPreleNew04 d V	% P
0		500	0.0			
71		500	0.0			
143		500	0.0			
214		500	0.0			
286		500	0.0			
357		500	0.0			
429		500	0.0			
500		500	0.0			
571		500	0.0			
643		500	0.0			
714		500	0.0			
786		500	0.0			
857		500	0.0			
929		500	0.0			
1000		500	0.0			


MISURE POTENZA IMPIEGATA PRIMARIO
TAU CONTROLLO PROCESSI
TAGLIAFERRI
TECHINT
U1010.7D
U1010.1D
PULSES U1010.5C
PULSES U1010.3C
PJ1100.1B
PJ1100.2B
4-20 mA POTENZA REATTIVA
4-20 mA POTENZA ATTIVA
6APQ_59556
RIVPLC1-111
FORMATO/SIZE A3
SCALA/SCALE 1:1
FORMO 1
1010
REV. 0
1009
1010-1
18/02/2002
02/05/2002
09/05/2002
E.B. PASSERA
E. CATTANEO
EPO
REV D 15/09/2005
B 10/07/2002


U1010.2H
CONTROLOORE / REGOLATORE ASCON
U1010.2G
DERIVATORE DI POTENZA REATTIVA
U1010.2E
DERIVATORE DI POTENZA ATTIVA
U1010.2F
CONTROLOORE / REGOLATORE ASCON
U1010.2D
TRASDUTTORE POTENZA ATTIVA E REATTIVA
POTENZA REATTIVA 0-20mA
POTENZA ATTIVA 0-20mA
LAMPADA SU PULPITO COMANDO FORNO
MISURE POTENZA IMPIEGATA PRIMARIO
TAU CONTROLLO PROCESSI
TAGLIAFERRI
TECHINT
6AMO_59550
15/09/2005