Reactive Power Management Through Capacitor & APFC

Context

Presentation Covers

- Rajasthan Bill Tariff
- Existing Bill Pattern
- What is Power Factor ?
- Why to Maintain ?
- How to Maintain
- Case Study

Rajasthan State

Rajasthan State having 3 Discoms

- Ajmer Vidyut Vitran Nigam Ltd
- Jaipur Vidyut Vitran Nigam Ltd.
- Jodhpur Vidyut Vitran Nigam Ltd.

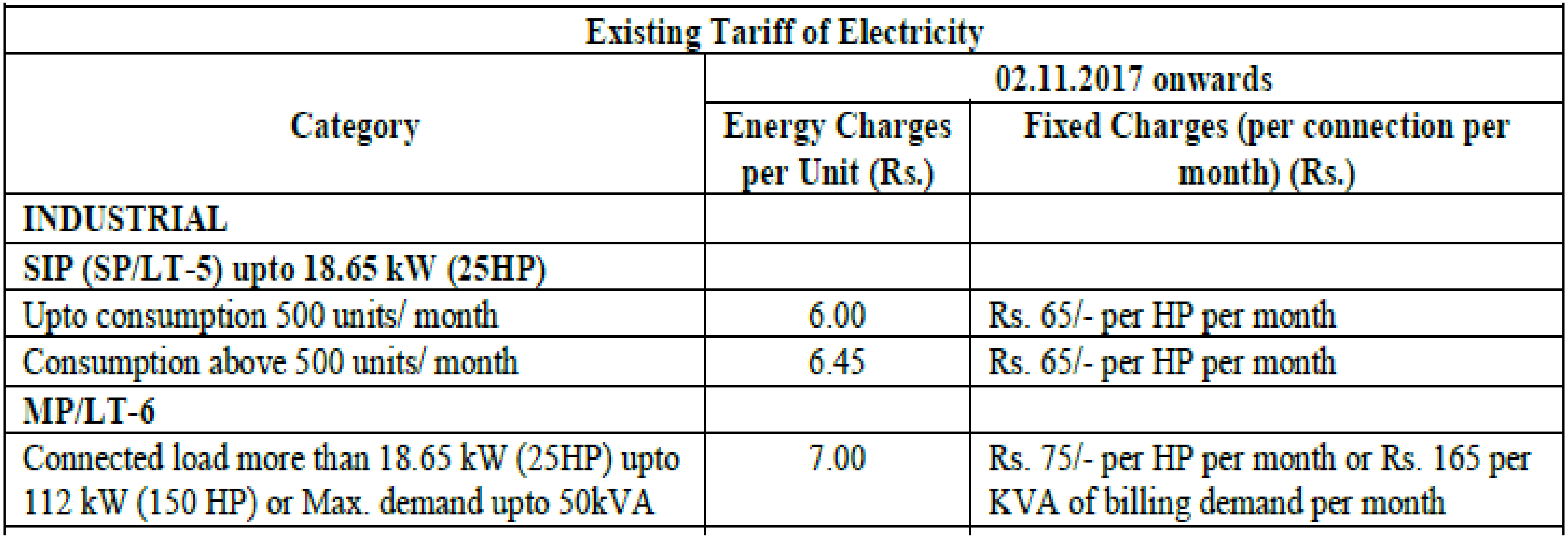
Following table is the contract demand and corresponding voltage for all 3 Discoms

Contract demand	Voltage of Supply kV
For Low and Medium	0.433
Upto 1500 KVA	11
Above 1500 KVA up to 5000 KVA	33
Above 5000 KVA	132 or 220

Rajasthan State

For the 3 Discoms (Vidyut Vitran Nigam of Rajasthan)

Billing is in kWh



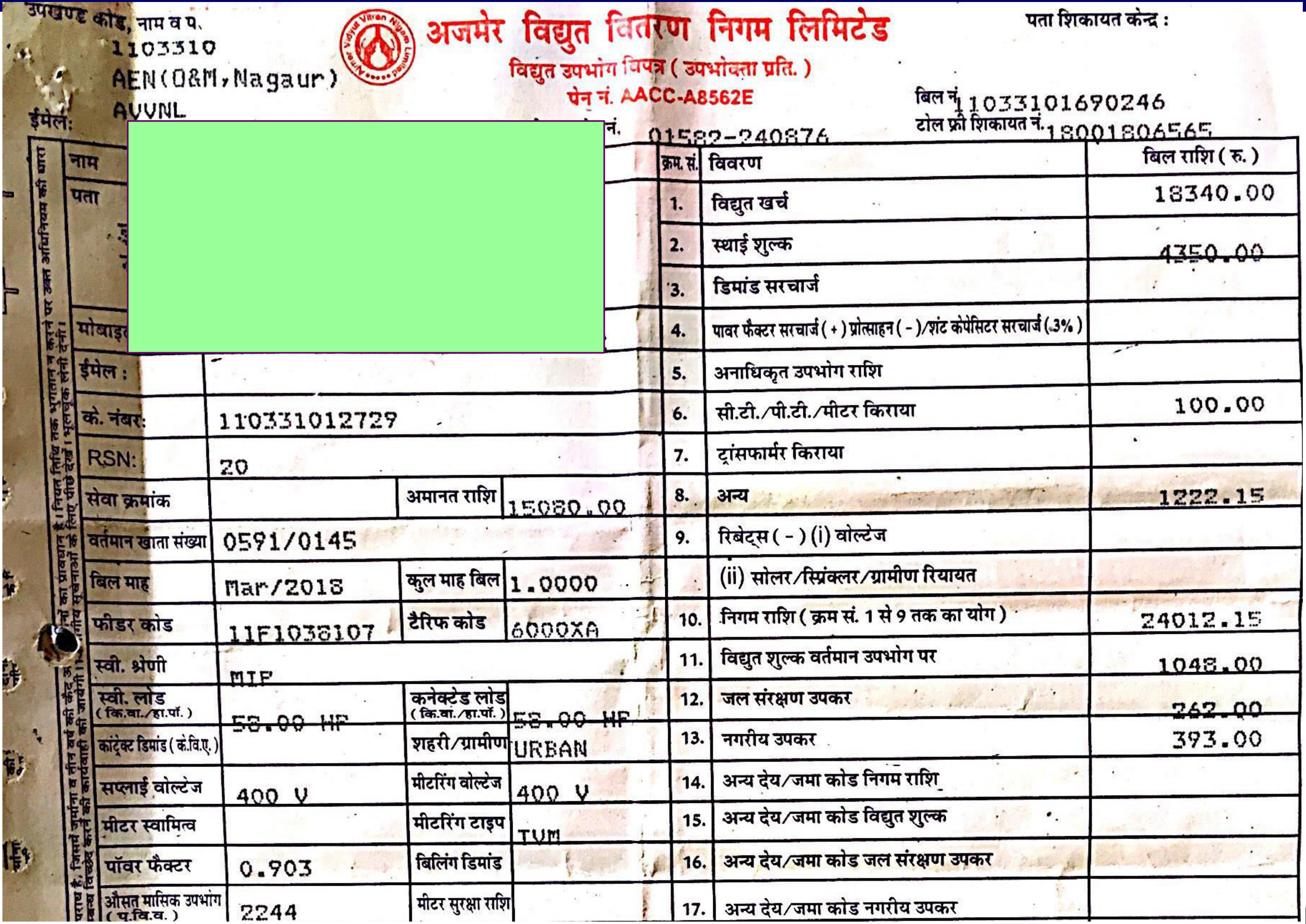
Existing Tariff of Electricity		
Category	02.11.2017 onwards	
	Energy Charges per Unit (Rs.)	Fixed Charges (per connection per month) (Rs.)
INDUSTRIAL		
SIP (SP/LT-5) upto 18.65 kW (25HP)		
Upto consumption 500 units/ month	6.00	Rs. 65/- per HP per month
Consumption above 500 units/ month	6.45	Rs. 65/- per HP per month
MP/LT-6		
Connected load more than 18.65 kW (25HP) upto 112 kW (150 HP) or Max. demand upto 50kVA	7.00	Rs. 75/- per HP per month or Rs. 165 per KVA of billing demand per month

Rajasthan State

Power factor Clause for all 3 Discoms of Rajasthan

- Consumer should have to maintain Power factor not less than 0.90.
- A surcharge at 0.1% of energy charges for energy 0.001 fall in average power below 0.900 shall be charged.
- An Incentive of 1% of Energy Charges shall be provided if the power factor is above 0.95 (95%) for each 0.01 (1%) improvement above 0.95 (95%).

Bill Structure



उपखण्ड कोड, नाम व प.
1103310
AEN(O&M,Nagaur)
AVVNL
ईमेल:

अजमेर विद्युत वितरण निगम लिमिटेड
विद्युत उपभोग विपत्र (उपभोक्ता प्रति.)
पेन नं. AACC-A8562E

पता शिकायत केन्द्र :

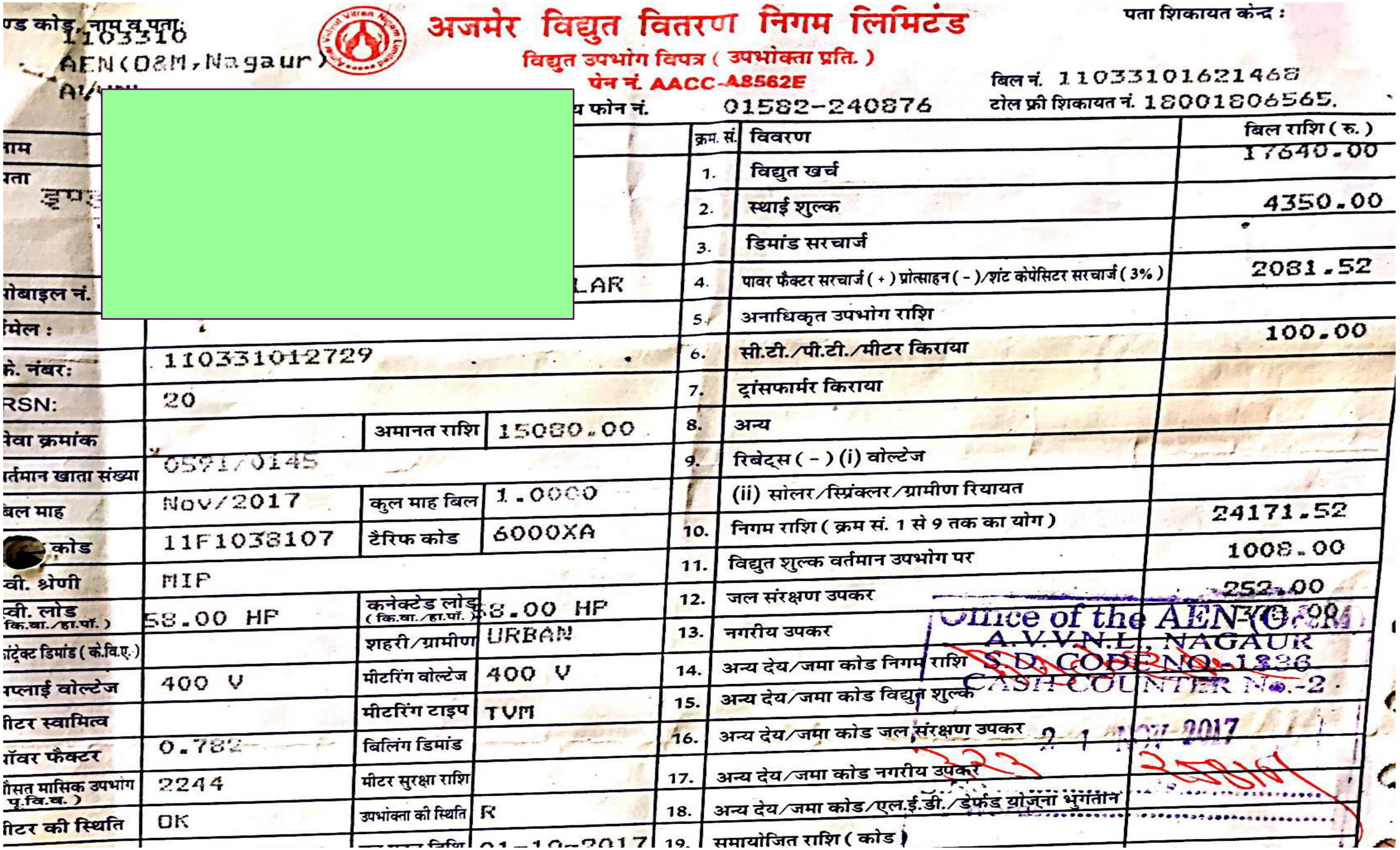
बिल नं. 1033101690246
टोल फ्री शिकायत नं. 18001806565

नं. 01582-240876

नाम	[redacted]		
पता	[redacted]		
मोबाइल	[redacted]		
ईमेल :			
के. नंबर:	110331012729		
RSN:	20		
सेवा क्रमांक		अमानत राशि	15080.00
वर्तमान खाता संख्या	0591/0145		
बिल माह	Mar/2018	कुल माह बिल	1.0000
फीडर कोड	11F1038107	टैरिफ कोड	6000XA
स्वी. श्रेणी	MIP		
स्वी. लोड (कि.वा./हा.पॉ.)	58.00 HP	कनेक्टेड लोड (कि.वा./हा.पॉ.)	58.00 HP
कांट्रेक्ट डिमांड (कं.वि.ए.)		शहरी/ग्रामीण	URBAN
सप्लाई वोल्टेज	400 V	मीटरिंग वोल्टेज	400 V
मीटर स्वामित्व		मीटरिंग टाइप	TVM
पॉवर फैक्टर	0.903	बिलिंग डिमांड	
औसत मासिक उपभोग (प.वि.व.)	2244	मीटर सुरक्षा राशि	

क्रम. सं.	विवरण	बिल राशि (रु.)
1.	विद्युत खर्च	18340.00
2.	स्थाई शुल्क	4350.00
3.	डिमांड सरचार्ज	
4.	पावर फैक्टर सरचार्ज (+) प्रोत्साहन (-)/शंट कपेसिटर सरचार्ज (.3%)	
5.	अनाधिकृत उपभोग राशि	
6.	सी.टी./पी.टी./मीटर किराया	100.00
7.	ट्रांसफार्मर किराया	
8.	अन्य	1222.15
9.	रिबेट्स (-) (i) वोल्टेज	
	(ii) सोलर/स्प्रिंक्लर/ग्रामीण रियायत	
10.	निगम राशि (क्रम सं. 1 से 9 तक का योग)	24012.15
11.	विद्युत शुल्क वर्तमान उपभोग पर	1048.00
12.	जल संरक्षण उपकर	262.00
13.	नगरीय उपकर	393.00
14.	अन्य देय/जमा कोड निगम राशि	
15.	अन्य देय/जमा कोड विद्युत शुल्क	
16.	अन्य देय/जमा कोड जल संरक्षण उपकर	
17.	अन्य देय/जमा कोड नगरीय उपकर	

Bill Structure



ण्ड कोड, नाम व पता:
1103310
AEN(O&M,Nagaur)
AV/

[redacted]

अजमेर विद्युत वितरण निगम लिमिटेड
विद्युत उपभोग विपत्र (उपभोक्ता प्रति.)
पेन नं. AACC-A8562E

पता शिकायत केन्द्र :

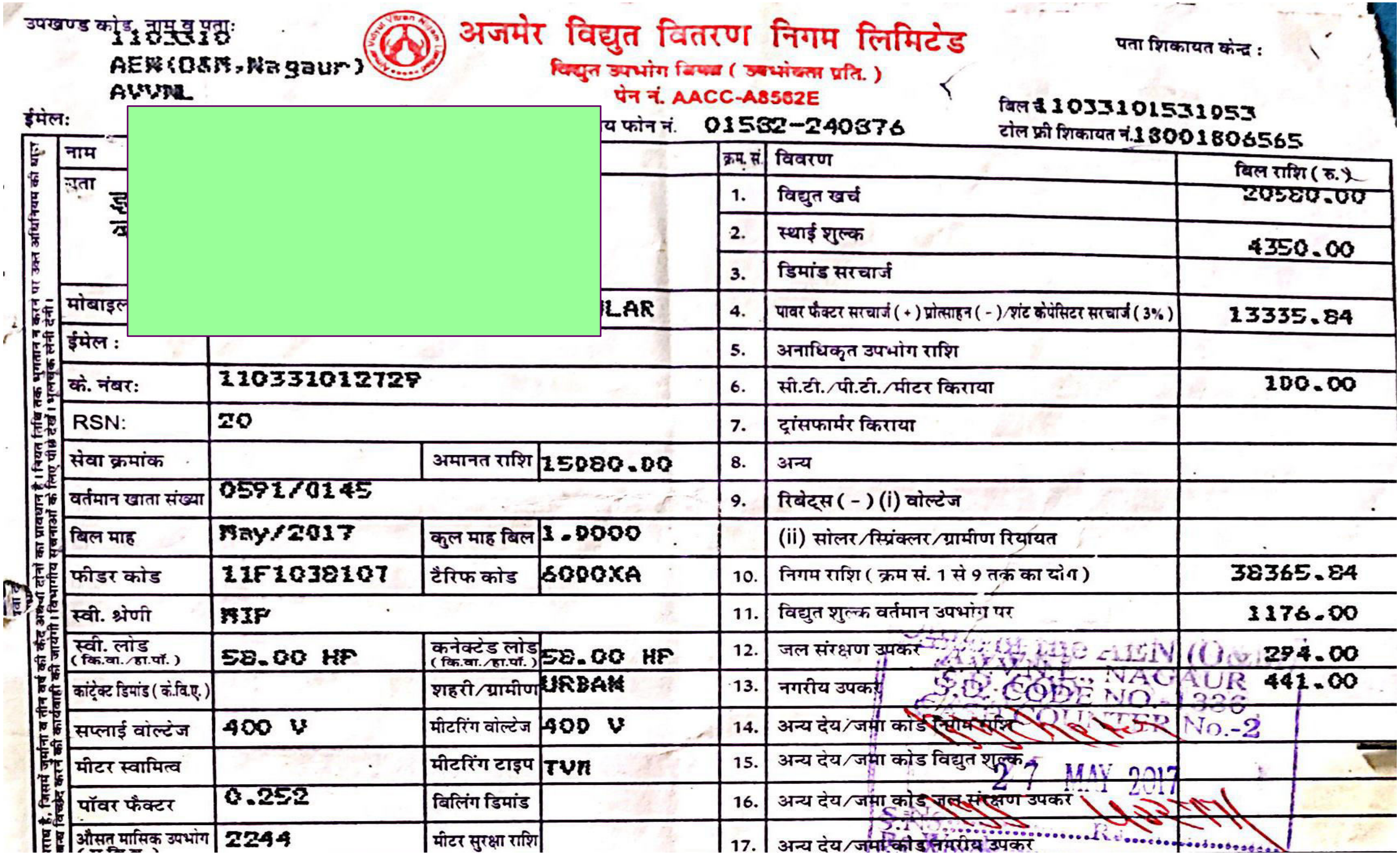
बिल नं. 11033101621468
य फोन नं. 01582-240876 टोल फ्री शिकायत नं. 18001806565.

ाम			
ता			
ोबाइल नं.	LAR		
्मेल :			
े. नंबर:	110331012729		
RSN:	20		
ेवा क्रमांक		अमानत राशि	15080.00
र्तमान खाता संख्या	0591/0145		
बल माह	Nov/2017	कुल माह बिल	1.0000
कोड	11F1038107	टैरिफ कोड	6000XA
वी. श्रेणी	MIP		
्वी. लोड (कि.वा./हा.पॉ.)	58.00 HP	कनेक्टेड लोड (कि.वा./हा.पॉ.)	58.00 HP
ांट्रेक्ट डिमांड (के.वि.ए.)		शहरी/ग्रामीण	URBAN
प्लाई वोल्टेज	400 V	मीटरिंग वोल्टेज	400 V
ीटर स्वामित्व		मीटरिंग टाइप	TVM
ॉवर फैक्टर	0.782	बिलिंग डिमांड	
ौसत मासिक उपभोग पू.वि.ख.)	2244	मीटर सुरक्षा राशि	
ीटर की स्थिति	OK	उपभोक्ता की स्थिति	R
			01-10-2017

क्रम. सं.	विवरण	बिल राशि (रु.)
1.	विद्युत खर्च	17640.00
2.	स्थाई शुल्क	4350.00
3.	डिमांड सरचार्ज	
4.	पावर फैक्टर सरचार्ज (+) प्रोत्साहन (-)/शंट कपेसिटर सरचार्ज (3%)	2081.52
5.	अनाधिकृत उपभोग राशि	
6.	सी.टी./पी.टी./मीटर किराया	100.00
7.	ट्रांसफार्मर किराया	
8.	अन्य	
9.	रिबेट्स (-) (i) वोल्टेज	
	(ii) सोलर/स्प्रिंक्लर/ग्रामीण रियायत	
10.	निगम राशि (क्रम सं. 1 से 9 तक का योग)	24171.52
11.	विद्युत शुल्क वर्तमान उपभोग पर	1008.00
12.	जल संरक्षण उपकर	252.00
13.	नगरीय उपकर	300.00
14.	अन्य देय/जमा कोड निगम राशि	
15.	अन्य देय/जमा कोड विद्युत शुल्क	
16.	अन्य देय/जमा कोड जल संरक्षण उपकर	
17.	अन्य देय/जमा कोड नगरीय उपकर	
18.	अन्य देय/जमा कोड/एल.ई.डी./डेफर्ड योजना भुगतान	
19.	समायोजित राशि (कोड)	

Office of the AEN (O&M)
A.V.V.N.L., NAGAUR
S.D. CODE NO.-1336
CASH COUNTER No.-2
21 NOV 2017

Bill Structure



उपखण्ड कोड, नाम व पता: 1103310
AEN(O&M,Nagaur)
AVVNL

अजमेर विद्युत वितरण निगम लिमिटेड
विद्युत उपभोग बिल (उपभोक्ता प्रति.)
पेन नं. AACC-A8562E

पता शिकायत केन्द्र :

ईमेल: [redacted] य फोन नं. 01582-240376

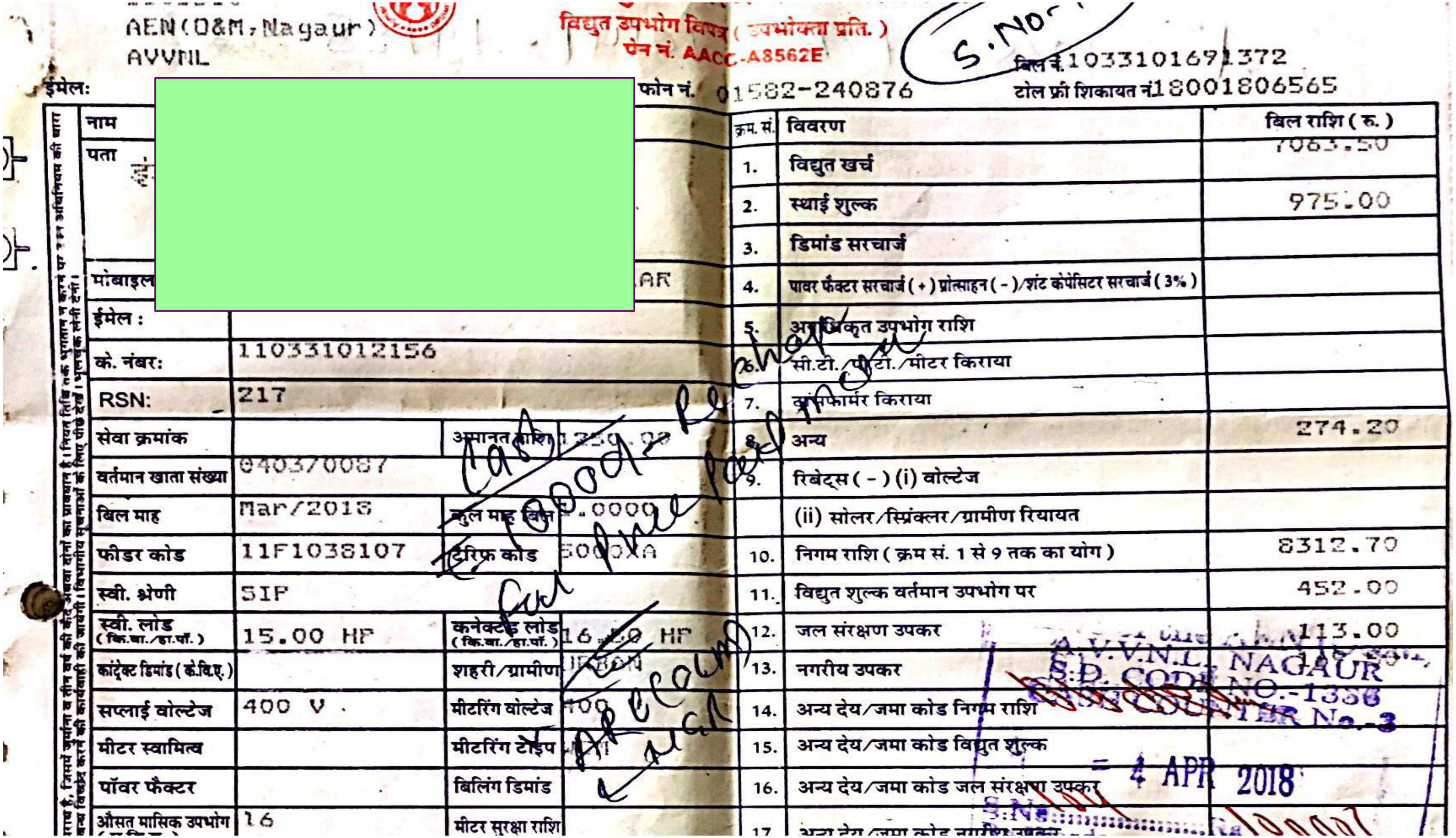
बिल नं. 1033101531053
टोल फ्री शिकायत नं.18001806565

नाम	[redacted]		
पता	[redacted]		
मोबाइल	[redacted] LAR		
ईमेल :			
के. नंबर:	110331012729		
RSN:	20		
सेवा क्रमांक		अमानत राशि	15080.00
वर्तमान खाता संख्या	0591/0145		
बिल माह	May/2017	कुल माह बिल	1.0000
फीडर कोड	11F1038107	टैरिफ कोड	6000XA
स्वी. श्रेणी	MIP		
स्वी. लोड (कि.वा./हा.पॉ.)	58.00 HP	कनेक्टेड लोड (कि.वा./हा.पॉ.)	58.00 HP
कांट्रेक्ट डिमांड (के.वि.ए.)		शहरी/ग्रामीण	URBAN
सप्लाई वोल्टेज	400 V	मीटरिंग वोल्टेज	400 V
मीटर स्वामित्व		मीटरिंग टाइप	TVM
पॉवर फैक्टर	0.252	बिलिंग डिमांड	
औसत मासिक उपभोग	2244	मीटर सुरक्षा राशि	

क्रम. सं.	विवरण	बिल राशि (रु.)
1.	विद्युत खर्च	20580.00
2.	स्थाई शुल्क	4350.00
3.	डिमांड सरचार्ज	
4.	पावर फैक्टर सरचार्ज (+) प्रोत्साहन (-)/शंट केपेसिटर सरचार्ज (3%)	13335.84
5.	अनाधिकृत उपभोग राशि	
6.	सी.टी./पी.टी./मीटर किराया	100.00
7.	ट्रांसफार्मर किराया	
8.	अन्य	
9.	रिबेट्स (-) (i) वोल्टेज	
	(ii) सोलर/स्प्रिंक्लर/ग्रामीण रियायत	
10.	निगम राशि (क्रम सं. 1 से 9 तक का योग)	38365.84
11.	विद्युत शुल्क वर्तमान उपभोग पर	1176.00
12.	जल संरक्षण उपकर	294.00
13.	नगरीय उपकर	441.00
14.	अन्य देय/जमा कोड निगम राशि	
15.	अन्य देय/जमा कोड विद्युत शुल्क	
16.	अन्य देय/जमा कोड जल संरक्षण उपकर	
17.	अन्य देय/जमा कोड नगरीय उपकर	

O/o THE AEN (O&M)
AVVNL NAGAUR
S.D. CODE NO.-1336
CASH COUNTER No.-2
27 MAY 2017
S.No. .... R. ....

Bill Structure



AEN(O&M,Nagaur)
AVVNL

विद्युत उपभोग विपत्र (उपभोक्ता प्रति.)
पेन नं. AACC-A8562E

S.No.

बिल नं. 1033101691372

ईमेल: [redacted]

फोन नं. 01582-240876

टोल फ्री शिकायत नं.18001806565

नाम	[redacted]		
पता			
मोबाइल			
ईमेल :			
के. नंबर:	110331012156		
RSN:	217		
सेवा क्रमांक		अमानत राशि	1250.00
वर्तमान खाता संख्या	040370087		
बिल माह	Mar/2018	कुल माह बिल	1.0000
फीडर कोड	11F1038107	टैरिफ कोड	5000XA
स्वी. श्रेणी	SIP		
स्वी. लोड (कि.वा./हा.पॉ.)	15.00 HP	कनेक्टेड लोड (कि.वा./हा.पॉ.)	16.00 HP
कांट्रेक्ट डिमांड (के.वि.ए.)		शहरी/ग्रामीण	URBAN
सप्लाई वोल्टेज	400 V	मीटरिंग वोल्टेज	400
मीटर स्वामित्व		मीटरिंग टाईप	[illegible]
पॉवर फैक्टर		बिलिंग डिमांड	
औसत मासिक उपभोग	16	मीटर सुरक्षा राशि	

क्रम. सं.	विवरण	बिल राशि (रु.)
1.	विद्युत खर्च	7063.50
2.	स्थाई शुल्क	975.00
3.	डिमांड सरचार्ज	
4.	पावर फैक्टर सरचार्ज (+) प्रोत्साहन (-)/शंट केपेसिटर सरचार्ज (3%)	
5.	अनाधिकृत उपभोग राशि	
6.	सी.टी./पी.टी./मीटर किराया	
7.	ट्रांसफार्मर किराया	
8.	अन्य	274.20
9.	रिबेट्स (-) (i) वोल्टेज	
	(ii) सोलर/स्प्रिंक्लर/ग्रामीण रियायत	
10.	निगम राशि (क्रम सं. 1 से 9 तक का योग)	8312.70
11.	विद्युत शुल्क वर्तमान उपभोग पर	452.00
12.	जल संरक्षण उपकर	113.00
13.	नगरीय उपकर	
14.	अन्य देय/जमा कोड निगम राशि	
15.	अन्य देय/जमा कोड विद्युत शुल्क	
16.	अन्य देय/जमा कोड जल संरक्षण उपकर	

Cash ₹10000/- [illegible]

A.V.V.N.L. NAGAUR
S.D. CODE NO.-1336
CASH COUNTER No.-3
4 APR 2018

Power Factor

Introduction

Power Factor Basics

Two Types of Power In System

1. **Active Power**
2. **Reactive Power**

Power Factor

Active Power

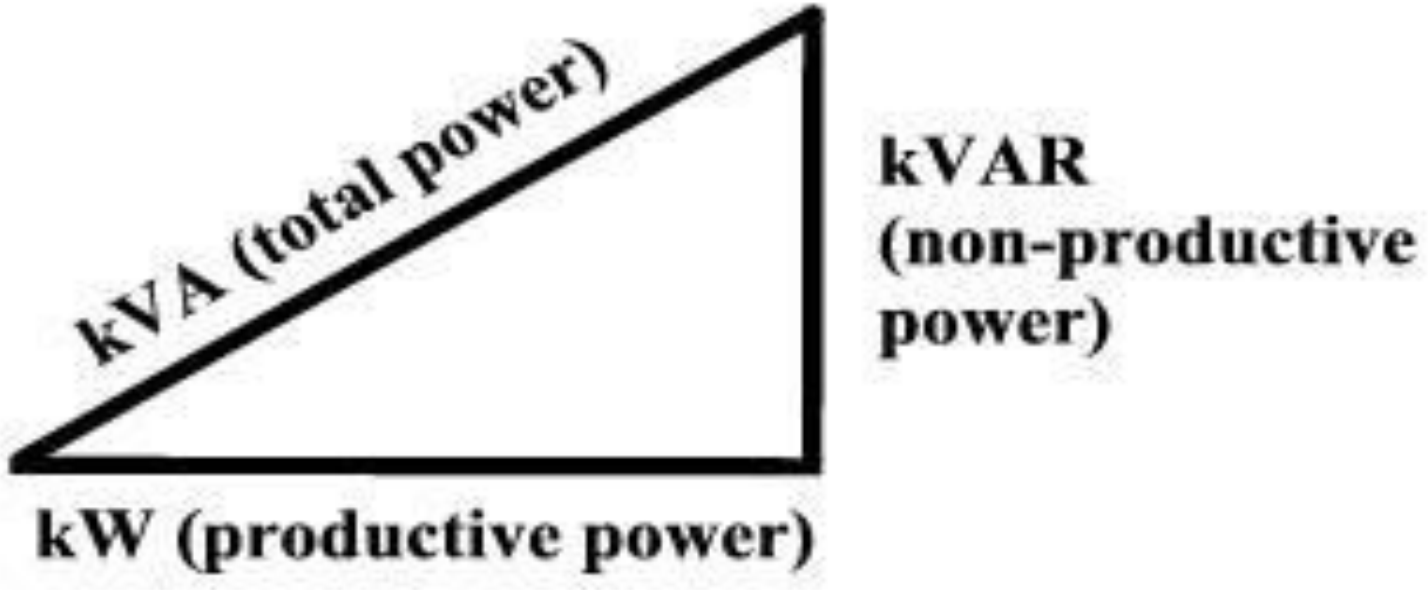
- This involves transfer of Real Power from system to end user
- When Voltage and Current are in Phase with each other

Power Factor

Reactive Power

- This involves establishment of Magnetic field or Electric Field
- No transfer of Real Power is involved
- When Voltage and Current are out of phase by 90o

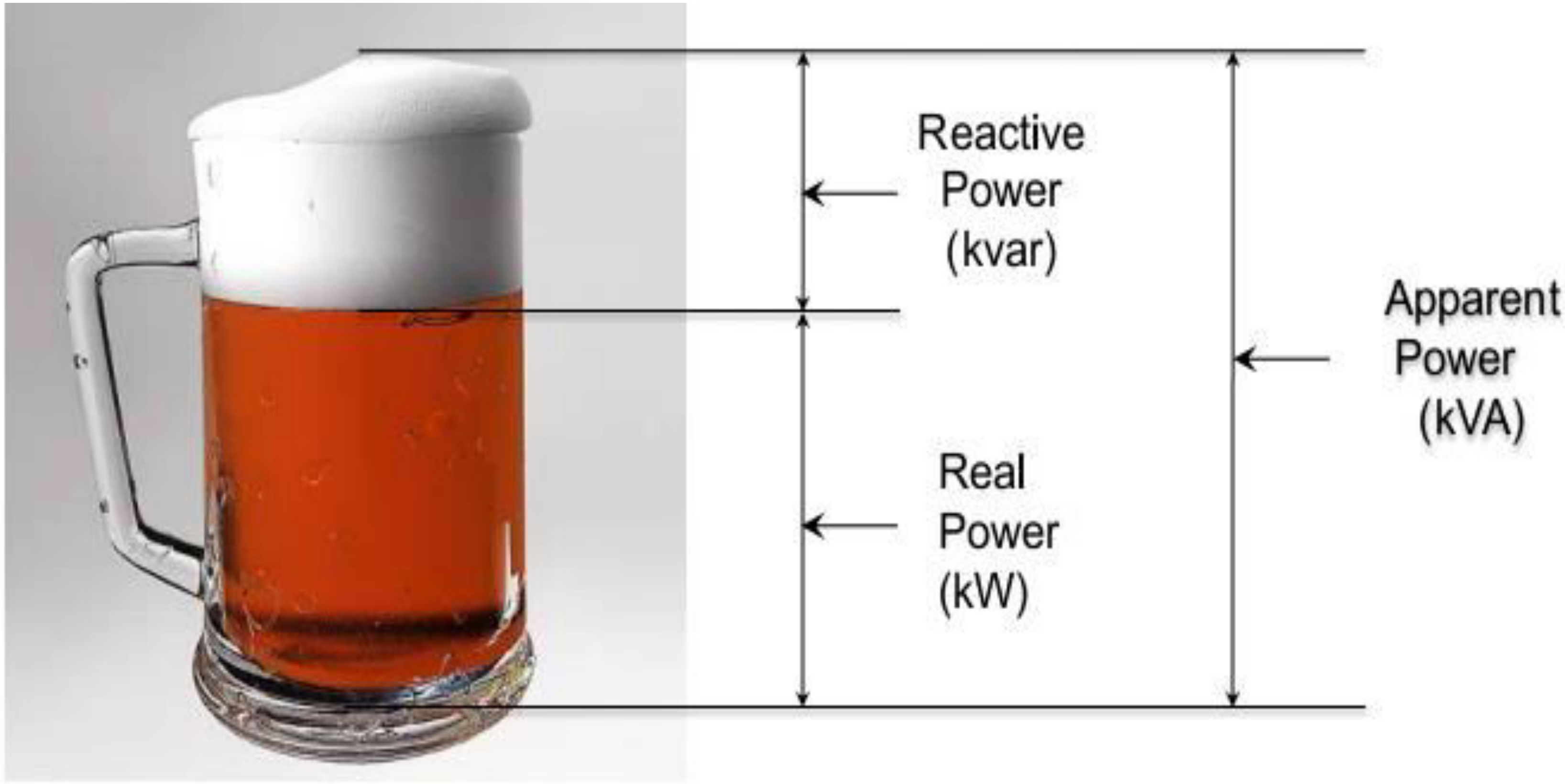
Power Triangle



$$\text{Power Factor} = \frac{\text{kW (productive power)}}{\text{kVA (total power)}}$$

Analogy

$$\text{Power factor} = \frac{kW}{KVA} = \frac{kW}{kW + KVAr} = \frac{Beer}{Beer + Foam}$$



Power Factor

How Poor operating power factor cost money?

- Maximum demand increases for the same load
- Draws more current for the same load
- More distribution voltage drop i.e loss in the distribution cable increase
- Copper loss in the transformer increase

Automatic Power Factor Controller (APFC)

Selection of APFC

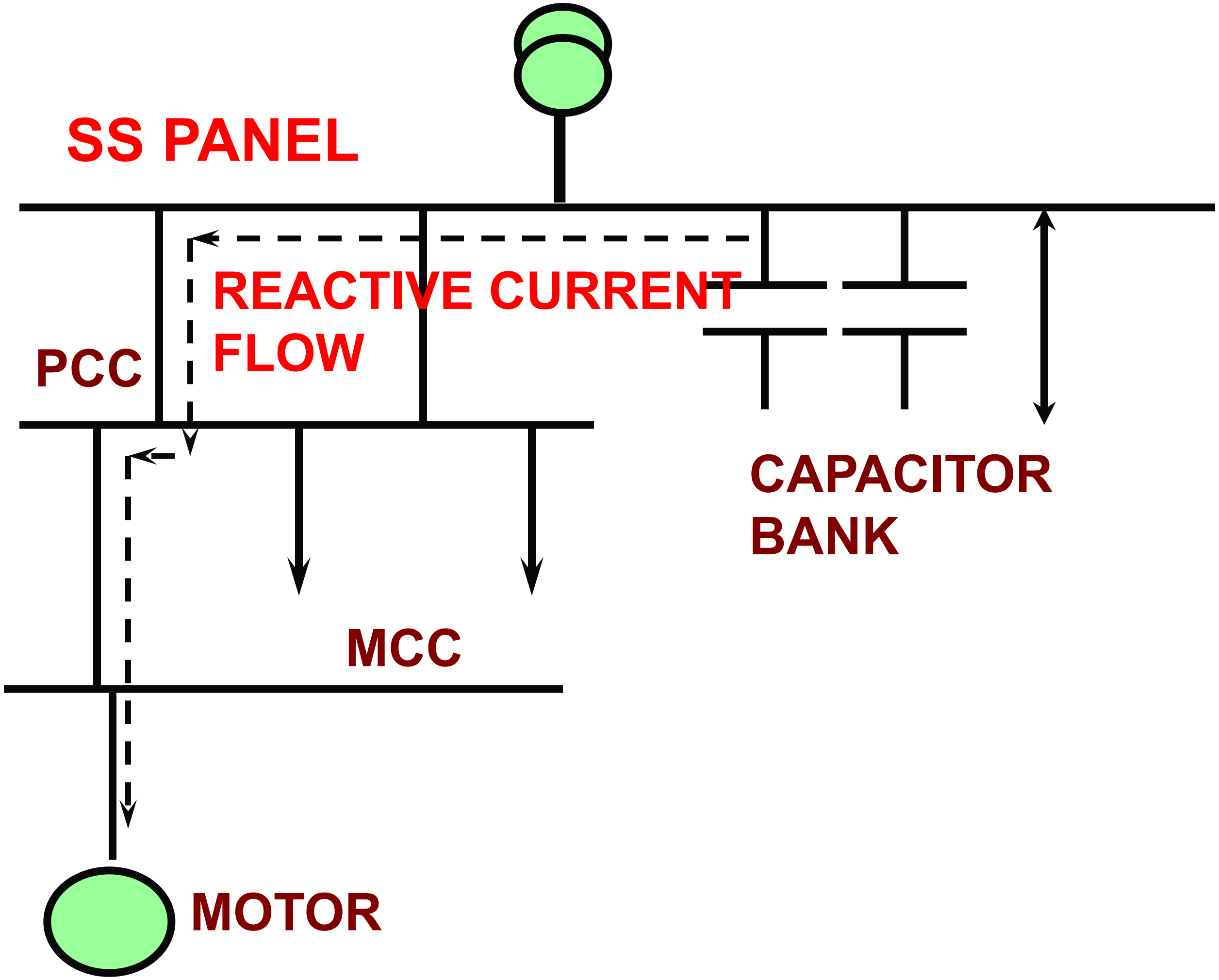
The category of APFC is generally 3 types.

- **Current - Sensing based APFC**
- **Power Factor Sensing based APFC**
- **kVAr Sensing based APFC**

Types of APFC Panels

- Contactor based APFC < 10 Sec
- Thyristors Based APFC < 1 Sec
- Microcontroller Based APFC < 5 milisec

Power Factor Compensation
Centralized compensation



Power Factor Compensation

Centralized Compensation

Advantages

- Easy P.F maintenance
- Capacitor maintenance easy

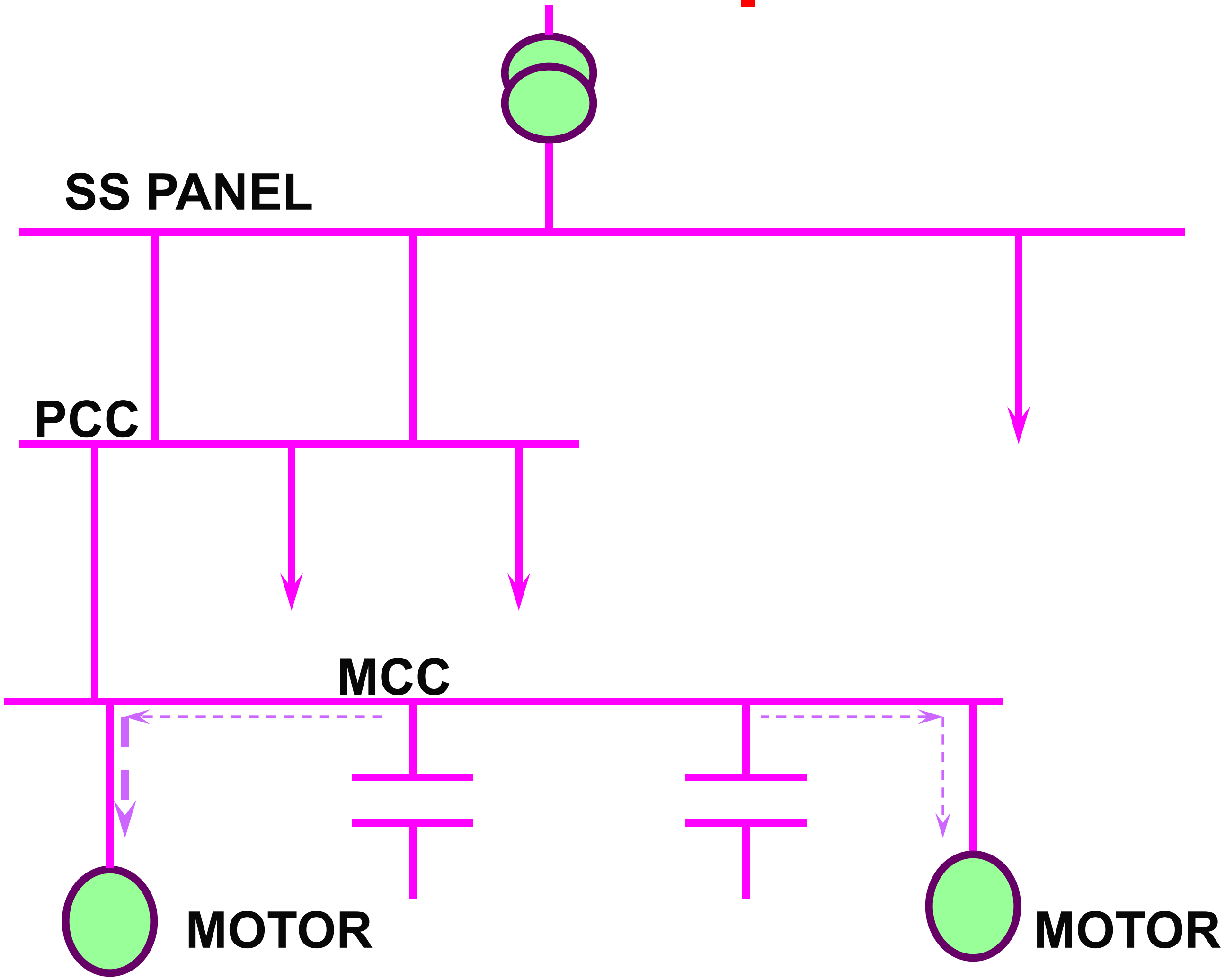
Disadvantages

- More voltage drop in distribution
- Over heating of cable resulting in failure

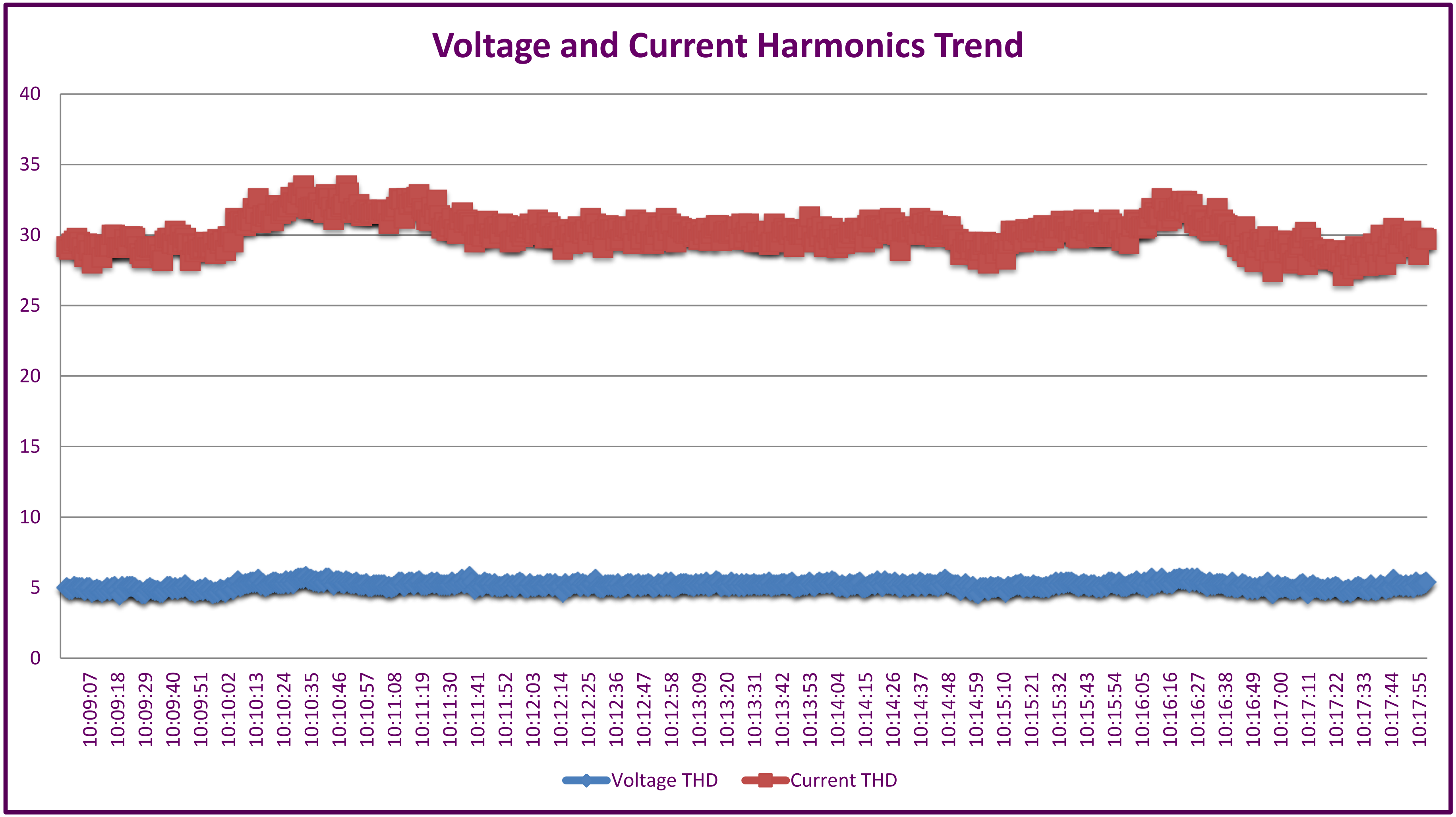
Common in engineering industry

Power Factor Compensation

Distributed Compensation

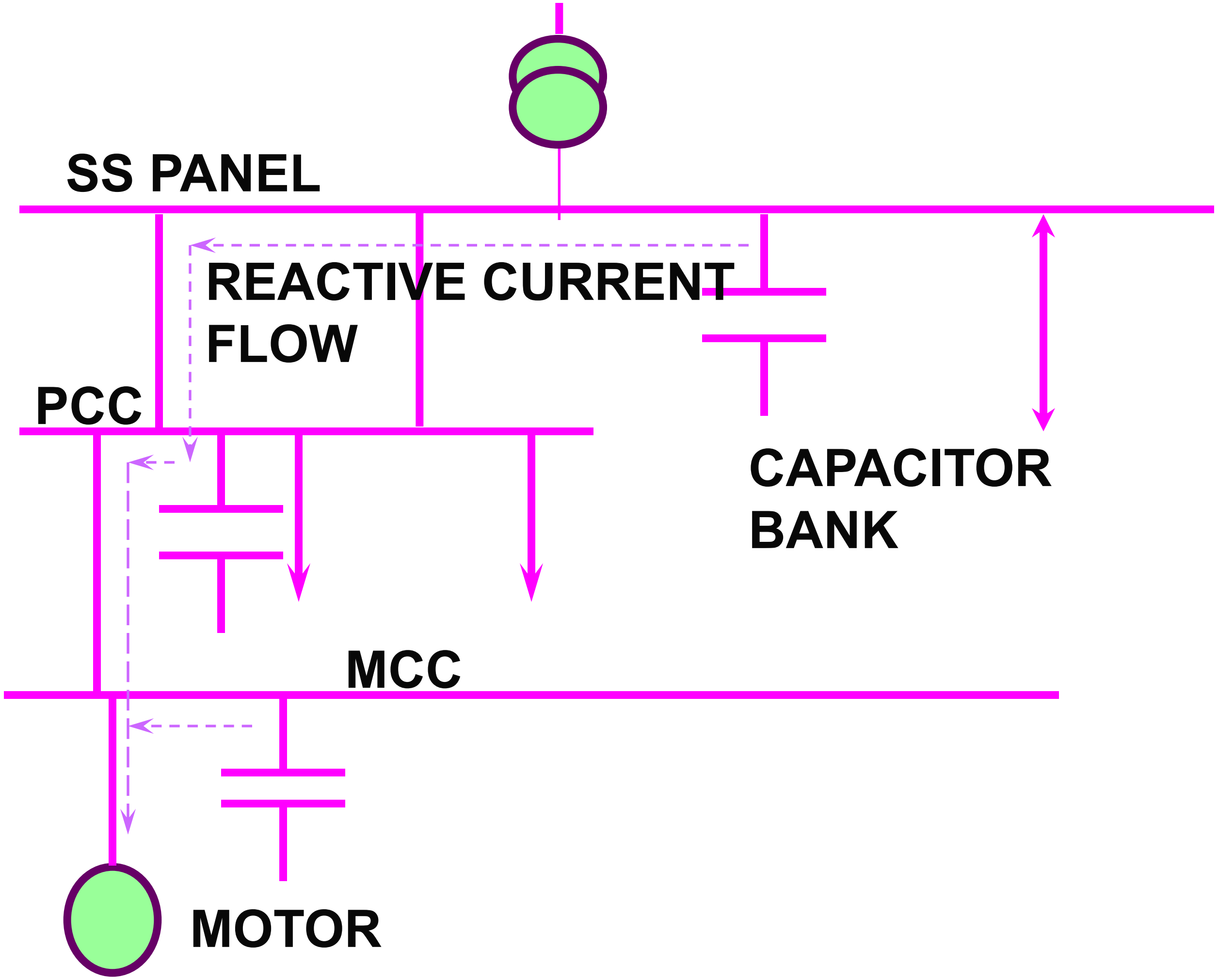


Power Factor Compensation



Power Factor Compensation

Mixed Compensation



Power Factor Compensation

Mixed Compensation

Advantages

- Good P.F control
- Easy maintenance
- Low distribution losses

Common in cement industry

IMPROVE OVERALL POWER FACTOR OF PLANT TO 0.99

- Electrical Distribution system studied
- Over all power factor 0.94-0.95
- Possibility to improve to unity

IMPROVE OVERALL POWER FACTOR OF PLANT TO 0.99

Power factor for last 11 months in Plant -1

Month & Year	Power Factor	Opportunity	Opportunity
		PF = 0.99	PF = 1.0
Apr-12	0.937	69776	77529
May-12	0.946	68279	75865
Jun-12	0.95	56257	62508
Jul-12	0.95	61542	68380
Aug-12	0.944	70029	77810
Sep-12	0.964	49614	55127
Oct-12	0.968	53986	59984
Nov-12	0.944	104064	115626
Dec-12	0.933	123211	136901
Jan-13	0.963	69454	77171
Feb-13	0.951	87105	96784
Total		813317	903685

IMPROVE OVERALL POWER FACTOR OF PLANT TO 0.99

Power factor for last 10 months in Plant -2

Month & Year	Power Factor	Opportunity	Opportunity
		PF = 0.99	PF = 1.0
May-12	0.921	83601	92889
Jun-12	0.904	92388	102654
Jul-12	0.955	50955	56617
Aug-12	0.95	59487	66096
Sep-12	0.929	102704	114116
Oct-12	0.923	137813	153125
Nov-12	0.932	201558	223953
Dec-12	0.966	59678	66309
Jan-13	0.963	134807	149786
Feb-13	0.944	134160	149067
Total		1057151	1174612

IMPROVE OVERALL POWER FACTOR OF PLANT TO 0.99

Bill Analysis

Plant	Avg. Power Factor	Total Bill Last FY 2012-13	Opportunity			
			PF = 0.99	% age	PF = 1.0	%age
Plant-1	0.950	2.32 Crores	8.87 Lakhs	3.83 %	9.86 Lakhs	4.26 %
Plant-2	0.939	2.33 Crores	12.69 Lakhs	5.44 %	14.10 Lakhs	6.04 %

IMPROVE OVERALL POWER FACTOR OF PLANT TO 0.99

Action Plan

- Maintenance of existing system
- Installation of APFC Panels at different areas

IMPROVE OVERALL POWER FACTOR OF PLANT TO 0.99

Capacitor Health Checkup 1250 KVA Transformer					
Capacitor Detail	Rating	Ideal Current	Current in Phases (Ampere)		
	KVAR	Ampere	R	Y	B
Capacitor No 1	25	28-30	15.5	8.8	8.8
Capacitor No 2	25	28-30	0	0	0
Capacitor No 3	25	28-30	20.1	20.8	20.2
Capacitor No 4	25	28-30	20.8	20.6	20.2
Capacitor No 5	25	28-30	0	0	0
Capacitor No 6	25	28-30	17.8	8.6	23.2
Capacitor No 7	25	28-30	0	0	0
Capacitor No 8	25	28-30	25.3	25.4	0
Capacitor No 9	25	28-30	19.3	20.3	21.8
Capacitor No 10	25	28-30	23.8	23.2	30.8
Capacitor No 11	25	28-30	28.3	28.9	29.7
Capacitor No 12	25	28-30	0	0	0
Capacitor No 13	25	28-30	29.6	29.3	29.7
Capacitor No 14	50	58-60	45	50.2	50.8
Capacitor No 15	50	58-60	53	61.4	53.1
Capacitor No 16	50	58-60	0	0	0
Capacitor No 17	50	58-60	34.2	37.4	28.5
Capacitor No 18	50	58-60	60.7	51.1	52.6
Capacitor No 19	50	58-60	53.1	52.8	61.2

IMPROVE OVERALL POWER FACTOR OF PLANT TO 0.99

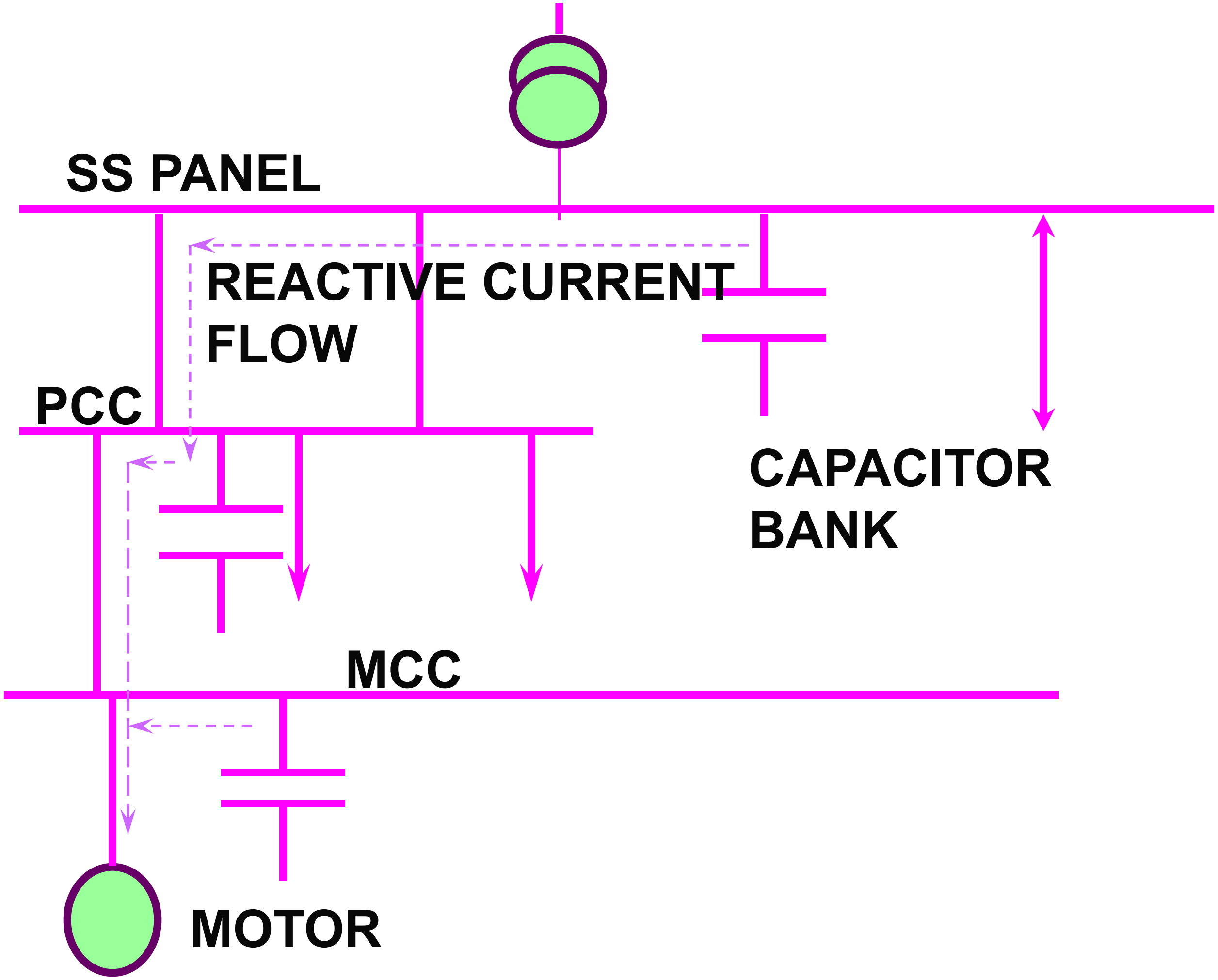
Capacitor Health Checkup 800 KVA Transformer					
Capacitor Detail	Rating	Ideal Current	Current in Phases (Ampere)		
	KVAR	Ampere	R	Y	B
Capacitor No 1	25	28-30	24.9	32	24.5
Capacitor No 2	25	28-30	28	28.6	27.4
Capacitor No 3	25	28-30	28.5	28.7	0
Capacitor No 4	25	28-30	27.4	57.6	66.7
Capacitor No 5	25	28-30	24.8	26.2	25
Capacitor No 6	50	58-60	54	52.4	32.3
Capacitor No 7	25	28-30	21.1	22.5	20.8
Capacitor No 8	50	58-60	55.7	0	55.8
Capacitor No 9	25	28-30	27.3	27.3	26.7
Capacitor No 10	25	28-30	32.7	32.4	32
Capacitor No 11	50	58-60	65.7	64.9	64.4
Capacitor No 12	25	28-30	32.6	32.2	32.4
Capacitor No 13	25	28-30	32.2	35	35.4
Capacitor No 14	25	28-30	32.5	32.4	32.1

IMPROVE OVERALL POWER FACTOR OF PLANT TO 0.99

Sr. No.	Section Description	Voltage	Currents	Power	Power Factor
		Volts	Amperes	kW	
1	Bonding and Tool Room	395	224	117	0.74
2	DTA Moulding 1	397	49	34	0.72
3	Accounts and Ship Compressor	397	47.7	29.7	0.9
4	Moulding Heavy line	395	47.8	28	0.83
5	DTA Moulding 2	392	316	177	0.85
6	DTA Finishing and Redeam	395	176	73	0.65
7	Compressor 500 CFM	397	137	82	0.87
8	EOU New Moulding	397	22.4	10.9	0.35
9	Press Shop	397	112	55	0.76
10	Clutch facing	397	316	202	0.93
11	Power House, Store DTA	426	22.6	16.75	0.72
12	OCV Finishing	427	117	68.5	0.79
13	OCV Basement DB1	427	97	68	0.95
14	OCV Basement Moulding DB2	427	125	78	0.82
15	OCV Lighting	427	11.7	7.2	0.89
16	Main Gate and Boundary Light	427	8.7	4.8	0.75
17	Moulding EOU	429	184	180	0.74
18	Dy 1 & 2	430	27.9	10	0.47
19	Moulding 3	431	120	78	0.86
20	4 Wheeler	434	41	22	0.68
21	Moulding 1	434	115	82	0.93

Power Factor Compensation

Mixed Compensation



IMPROVE OVERALL POWER FACTOR OF PLANT TO 0.99

Sr. No.	Section Description	Power Factor	Power kW	KVAR Required
1	Transformer 1250 KVA			250
2	Transformer 800 KVA			250
3	Bonding and Tool Room	0.74	117	125
4	DTA Moulding 2	0.85	177	125
5	DTA Finishing and Redeam	0.65	97	125
6	Clutch facing	0.93	202	100
7	OCV Finishing	0.79	68.5	100
8	OCV Basement Moulding DB2	0.82	78	100
9	Moulding EOU	0.74	180	150

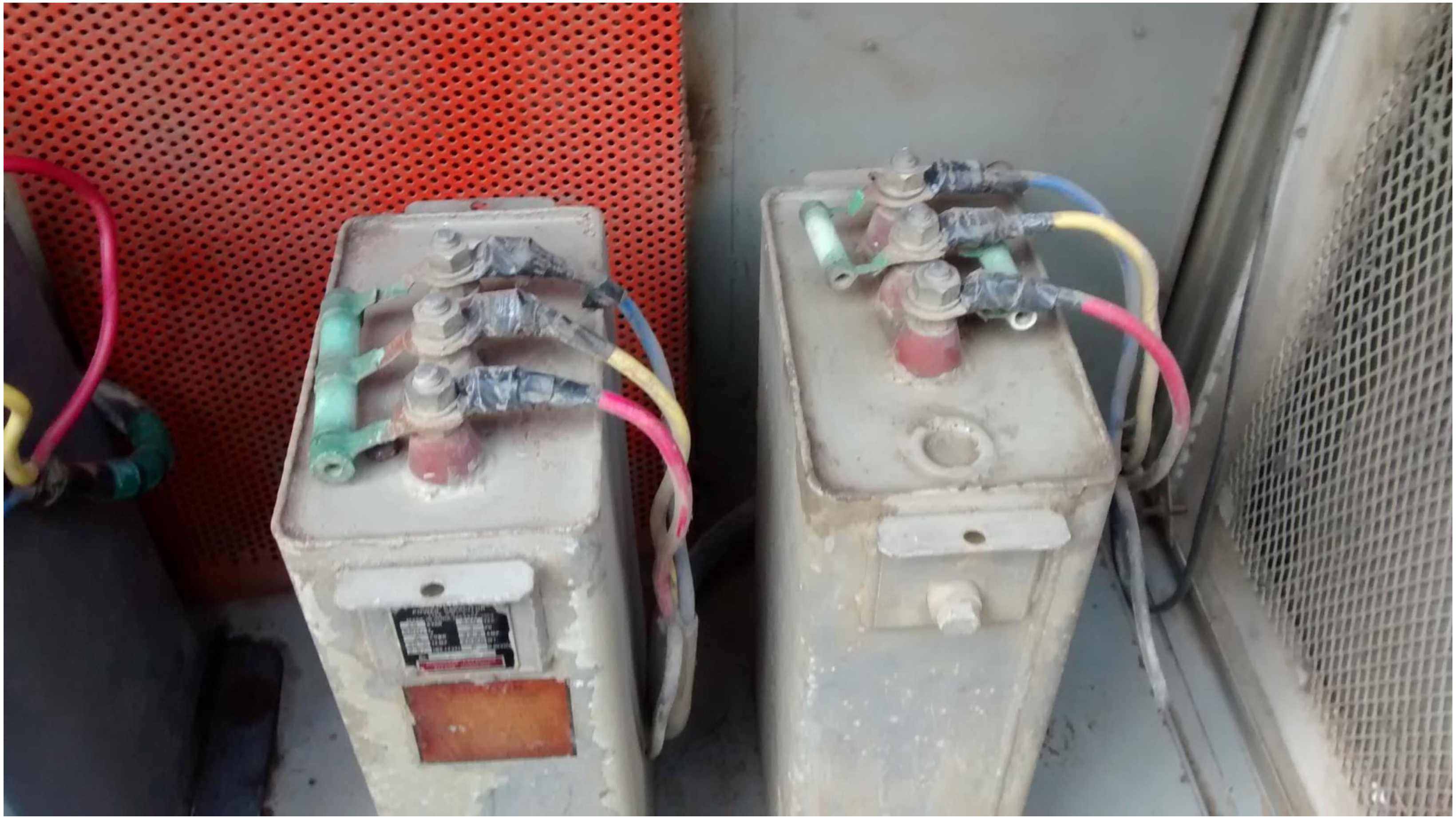
Power Capacitors

- Capacitor banks install to improve power factor

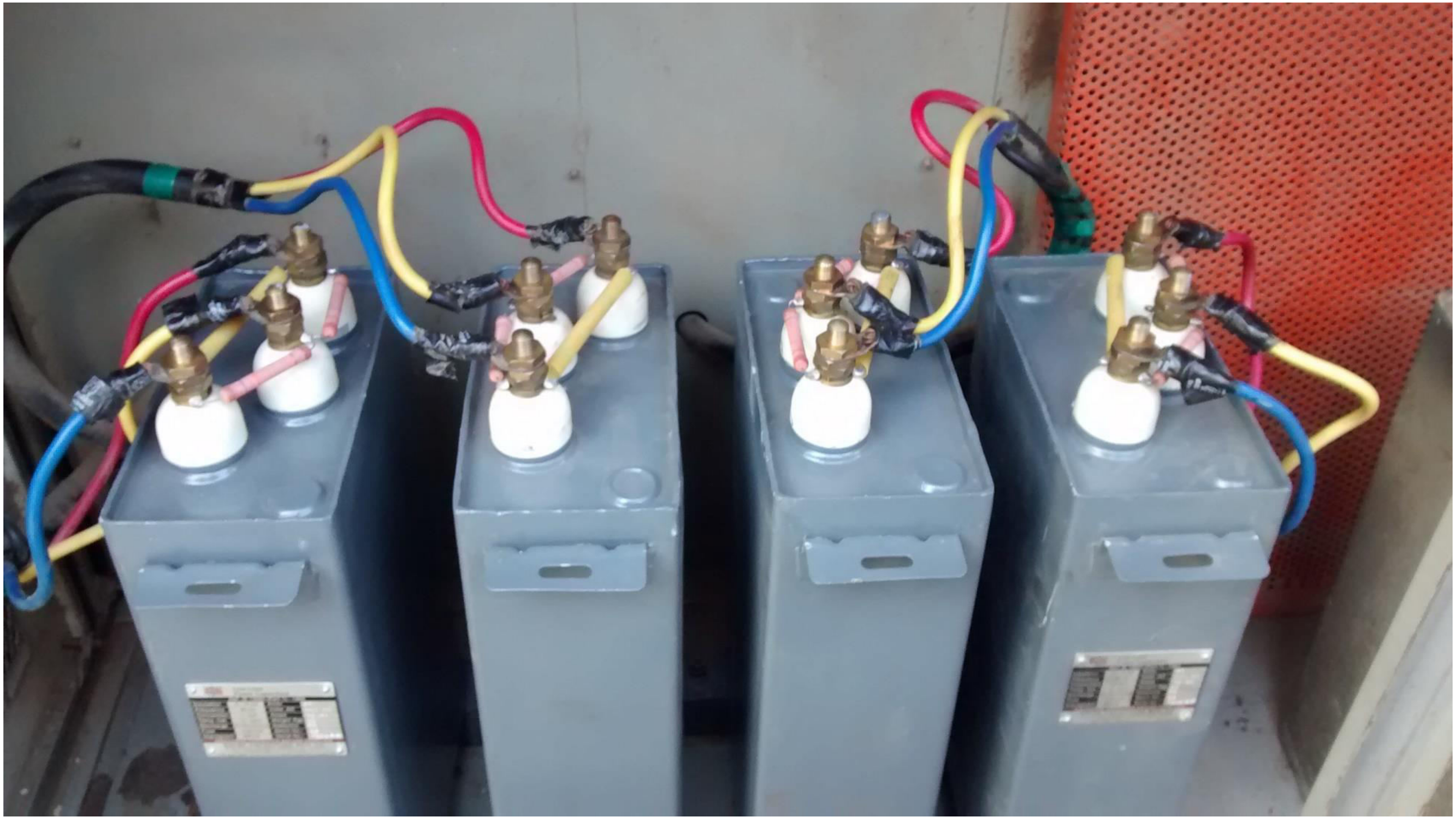
Reasons for failure

- Ageing
- Input voltage and frequency fluctuation
- Harmonics present in the system
- Temperature around the bank
- Poor quality capacitors use in the construction

Power Capacitors



Power Capacitors



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IMPROVE OVERALL POWER FACTOR OF PLANT TO 0.99

Savings = Rs. 8.87 Lakhs + Rs. 12.69= Rs. 21.56 Lakhs

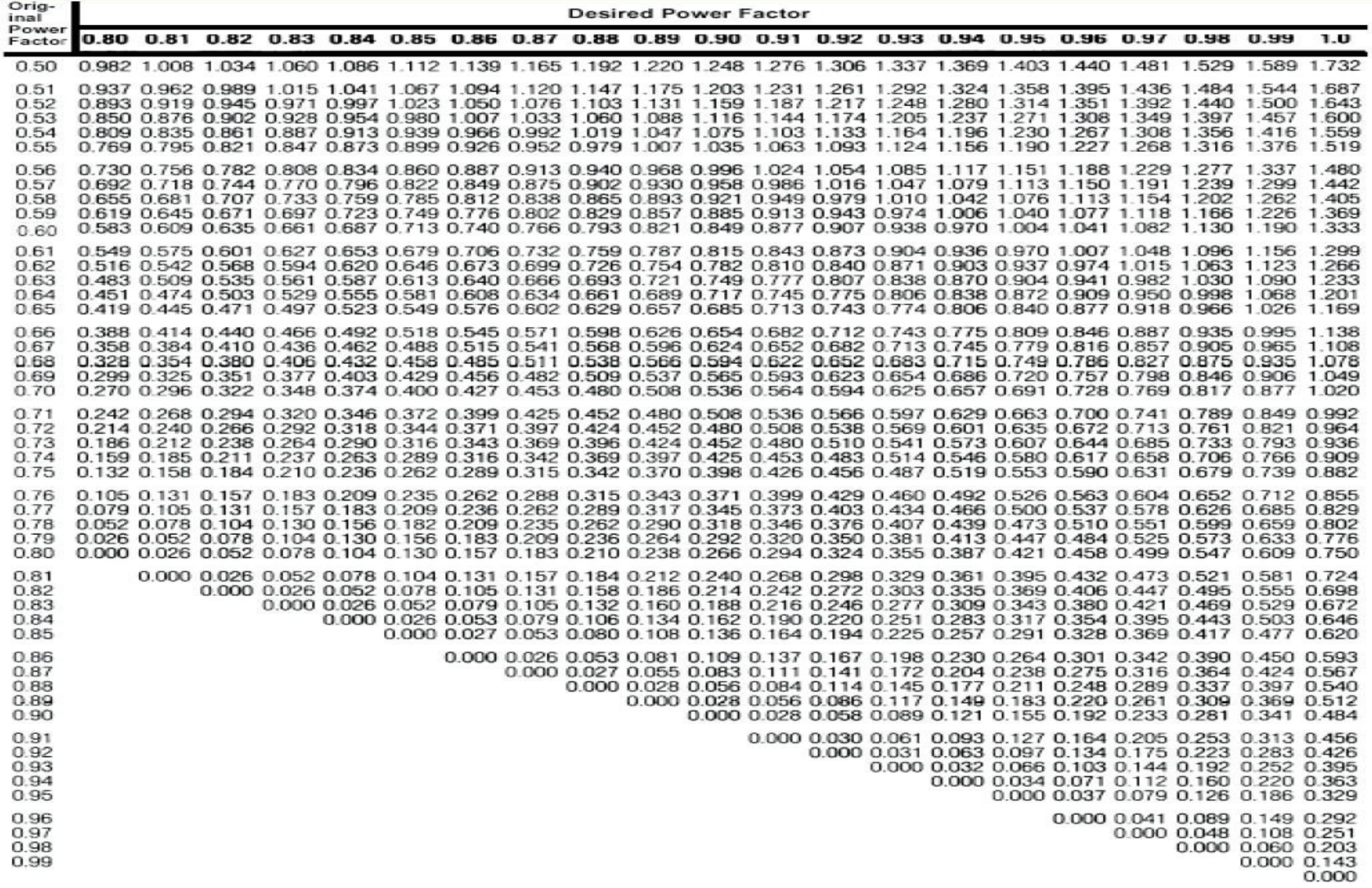
Annual Saving - Rs 21.56 Lakhs
Investment - Rs 12.00 Lakhs
Pay Back - 7 Months

Capacitor Selection

- **Chart Method**
- **Formula Method**
  - Capacitor required (KVAr)

    = kW x {Tan cos-1Φ_1 – Tan cos-1Φ_2 }
  - Cos Φ1 – Present power factor
  - Cos Φ2 – Desired power factor

TABLE 1.2 MULTIPLIERS TO DETERMINE CAPACITOR kVAr REQUIREMENTS FOR POWER FACTOR CORRECTION

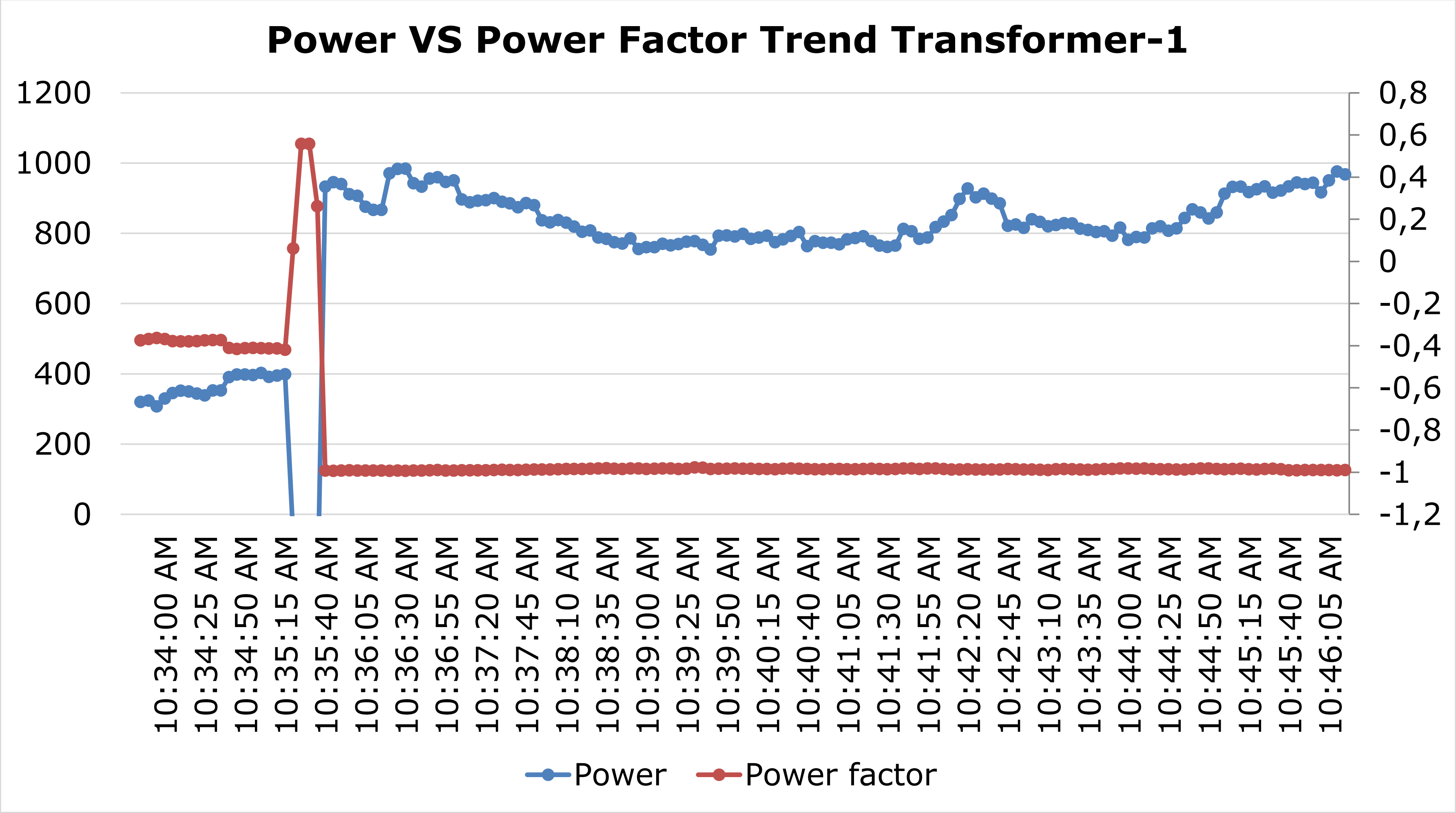


Original Power Factor	Desired Power Factor																				
	0.80	**0.81**	**0.82**	**0.83**	**0.84**	**0.85**	**0.86**	**0.87**	**0.88**	**0.89**	**0.90**	**0.91**	**0.92**	**0.93**	**0.94**	**0.95**	**0.96**	**0.97**	**0.98**	**0.99**	**1.0**
0.50	0.982	1.008	1.034	1.060	1.086	1.112	1.139	1.165	1.192	1.220	1.248	1.276	1.306	1.337	1.369	1.403	1.440	1.481	1.529	1.589	1.732
0.51	0.937	0.962	0.989	1.015	1.041	1.067	1.094	1.120	1.147	1.175	1.203	1.231	1.261	1.292	1.324	1.358	1.395	1.436	1.484	1.544	1.687
0.52	0.893	0.919	0.945	0.971	0.997	1.023	1.050	1.076	1.103	1.131	1.159	1.187	1.217	1.248	1.280	1.314	1.351	1.392	1.440	1.500	1.643
0.53	0.850	0.876	0.902	0.928	0.954	0.980	1.007	1.033	1.060	1.088	1.116	1.144	1.174	1.205	1.237	1.271	1.308	1.349	1.397	1.457	1.600
0.54	0.809	0.835	0.861	0.887	0.913	0.939	0.966	0.992	1.019	1.047	1.075	1.103	1.133	1.164	1.196	1.230	1.267	1.308	1.356	1.416	1.559
0.55	0.769	0.795	0.821	0.847	0.873	0.899	0.926	0.952	0.979	1.007	1.035	1.063	1.093	1.124	1.156	1.190	1.227	1.268	1.316	1.376	1.519
0.56	0.730	0.756	0.782	0.808	0.834	0.860	0.887	0.913	0.940	0.968	0.996	1.024	1.054	1.085	1.117	1.151	1.188	1.229	1.277	1.337	1.480
0.57	0.692	0.718	0.744	0.770	0.796	0.822	0.849	0.875	0.902	0.930	0.958	0.986	1.016	1.047	1.079	1.113	1.150	1.191	1.239	1.299	1.442
0.58	0.655	0.681	0.707	0.733	0.759	0.785	0.812	0.838	0.865	0.893	0.921	0.949	0.979	1.010	1.042	1.076	1.113	1.154	1.202	1.262	1.405
0.59	0.619	0.645	0.671	0.697	0.723	0.749	0.776	0.802	0.829	0.857	0.885	0.913	0.943	0.974	1.006	1.040	1.077	1.118	1.166	1.226	1.369
0.60	0.583	0.609	0.635	0.661	0.687	0.713	0.740	0.766	0.793	0.821	0.849	0.877	0.907	0.938	0.970	1.004	1.041	1.082	1.130	1.190	1.333
0.61	0.549	0.575	0.601	0.627	0.653	0.679	0.706	0.732	0.759	0.787	0.815	0.843	0.873	0.904	0.936	0.970	1.007	1.048	1.096	1.156	1.299
0.62	0.516	0.542	0.568	0.594	0.620	0.646	0.673	0.699	0.726	0.754	0.782	0.810	0.840	0.871	0.903	0.937	0.974	1.015	1.063	1.123	1.266
0.63	0.483	0.509	0.535	0.561	0.587	0.613	0.640	0.666	0.693	0.721	0.749	0.777	0.807	0.838	0.870	0.904	0.941	0.982	1.030	1.090	1.233
0.64	0.451	0.474	0.503	0.529	0.555	0.581	0.608	0.634	0.661	0.689	0.717	0.745	0.775	0.806	0.838	0.872	0.909	0.950	0.998	1.068	1.201
0.65	0.419	0.445	0.471	0.497	0.523	0.549	0.576	0.602	0.629	0.657	0.685	0.713	0.743	0.774	0.806	0.840	0.877	0.918	0.966	1.026	1.169
0.66	0.388	0.414	0.440	0.466	0.492	0.518	0.545	0.571	0.598	0.626	0.654	0.682	0.712	0.743	0.775	0.809	0.846	0.887	0.935	0.995	1.138
0.67	0.358	0.384	0.410	0.436	0.462	0.488	0.515	0.541	0.568	0.596	0.624	0.652	0.682	0.713	0.745	0.779	0.816	0.857	0.905	0.965	1.108
0.68	0.328	0.354	0.380	0.406	0.432	0.458	0.485	0.511	0.538	0.566	0.594	0.622	0.652	0.683	0.715	0.749	0.786	0.827	0.875	0.935	1.078
0.69	0.299	0.325	0.351	0.377	0.403	0.429	0.456	0.482	0.509	0.537	0.565	0.593	0.623	0.654	0.686	0.720	0.757	0.798	0.846	0.906	1.049
0.70	0.270	0.296	0.322	0.348	0.374	0.400	0.427	0.453	0.480	0.508	0.536	0.564	0.594	0.625	0.657	0.691	0.728	0.769	0.817	0.877	1.020
0.71	0.242	0.268	0.294	0.320	0.346	0.372	0.399	0.425	0.452	0.480	0.508	0.536	0.566	0.597	0.629	0.663	0.700	0.741	0.789	0.849	0.992
0.72	0.214	0.240	0.266	0.292	0.318	0.344	0.371	0.397	0.424	0.452	0.480	0.508	0.538	0.569	0.601	0.635	0.672	0.713	0.761	0.821	0.964
0.73	0.186	0.212	0.238	0.264	0.290	0.316	0.343	0.369	0.396	0.424	0.452	0.480	0.510	0.541	0.573	0.607	0.644	0.685	0.733	0.793	0.936
0.74	0.159	0.185	0.211	0.237	0.263	0.289	0.316	0.342	0.369	0.397	0.425	0.453	0.483	0.514	0.546	0.580	0.617	0.658	0.706	0.766	0.909
0.75	0.132	0.158	0.184	0.210	0.236	0.262	0.289	0.315	0.342	0.370	0.398	0.426	0.456	0.487	0.519	0.553	0.590	0.631	0.679	0.739	0.882
0.76	0.105	0.131	0.157	0.183	0.209	0.235	0.262	0.288	0.315	0.343	0.371	0.399	0.429	0.460	0.492	0.526	0.563	0.604	0.652	0.712	0.855
0.77	0.079	0.105	0.131	0.157	0.183	0.209	0.236	0.262	0.289	0.317	0.345	0.373	0.403	0.434	0.466	0.500	0.537	0.578	0.626	0.685	0.829
0.78	0.052	0.078	0.104	0.130	0.156	0.182	0.209	0.235	0.262	0.290	0.318	0.346	0.376	0.407	0.439	0.473	0.510	0.551	0.599	0.659	0.802
0.79	0.026	0.052	0.078	0.104	0.130	0.156	0.183	0.209	0.236	0.264	0.292	0.320	0.350	0.381	0.413	0.447	0.484	0.525	0.573	0.633	0.776
0.80	0.000	0.026	0.052	0.078	0.104	0.130	0.157	0.183	0.210	0.238	0.266	0.294	0.324	0.355	0.387	0.421	0.458	0.499	0.547	0.609	0.750
0.81		0.000	0.026	0.052	0.078	0.104	0.131	0.157	0.184	0.212	0.240	0.268	0.298	0.329	0.361	0.395	0.432	0.473	0.521	0.581	0.724
0.82			0.000	0.026	0.052	0.078	0.105	0.131	0.158	0.186	0.214	0.242	0.272	0.303	0.335	0.369	0.406	0.447	0.495	0.555	0.698
0.83				0.000	0.026	0.052	0.079	0.105	0.132	0.160	0.188	0.216	0.246	0.277	0.309	0.343	0.380	0.421	0.469	0.529	0.672
0.84					0.000	0.026	0.053	0.079	0.106	0.134	0.162	0.190	0.220	0.251	0.283	0.317	0.354	0.395	0.443	0.503	0.646
0.85						0.000	0.027	0.053	0.080	0.108	0.136	0.164	0.194	0.225	0.257	0.291	0.328	0.369	0.417	0.477	0.620
0.86							0.000	0.026	0.053	0.081	0.109	0.137	0.167	0.198	0.230	0.264	0.301	0.342	0.390	0.450	0.593
0.87								0.000	0.027	0.055	0.083	0.111	0.141	0.172	0.204	0.238	0.275	0.316	0.364	0.424	0.567
0.88									0.000	0.028	0.056	0.084	0.114	0.145	0.177	0.211	0.248	0.289	0.337	0.397	0.540
0.89										0.000	0.028	0.056	0.086	0.117	0.149	0.183	0.220	0.261	0.309	0.369	0.512
0.90											0.000	0.028	0.058	0.089	0.121	0.155	0.192	0.233	0.281	0.341	0.484
0.91												0.000	0.030	0.061	0.093	0.127	0.164	0.205	0.253	0.313	0.456
0.92													0.000	0.031	0.063	0.097	0.134	0.175	0.223	0.283	0.426
0.93														0.000	0.032	0.066	0.103	0.144	0.192	0.252	0.395
0.94															0.000	0.034	0.071	0.112	0.160	0.220	0.363
0.95																0.000	0.037	0.079	0.126	0.186	0.329
0.96																	0.000	0.041	0.089	0.149	0.292
0.97																		0.000	0.048	0.108	0.251
0.98																			0.000	0.060	0.203
0.99																				0.000	0.143
																					0.000

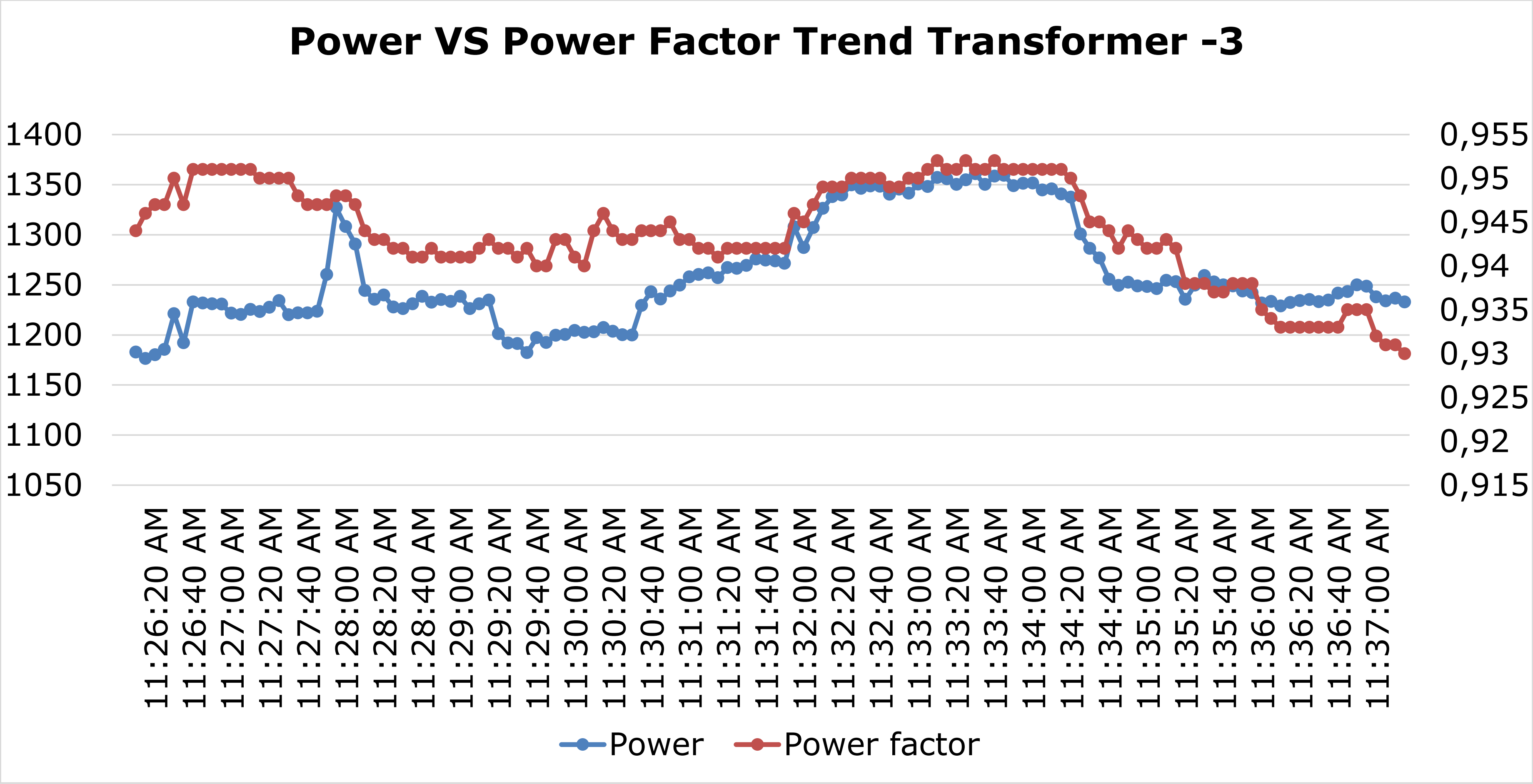
Power Factor Study of Plant

- Electrical Distribution system studied –
- Billing analysis done for last 1 Year
- Average power factor - 0.998

Transformer loading



Transformer loading



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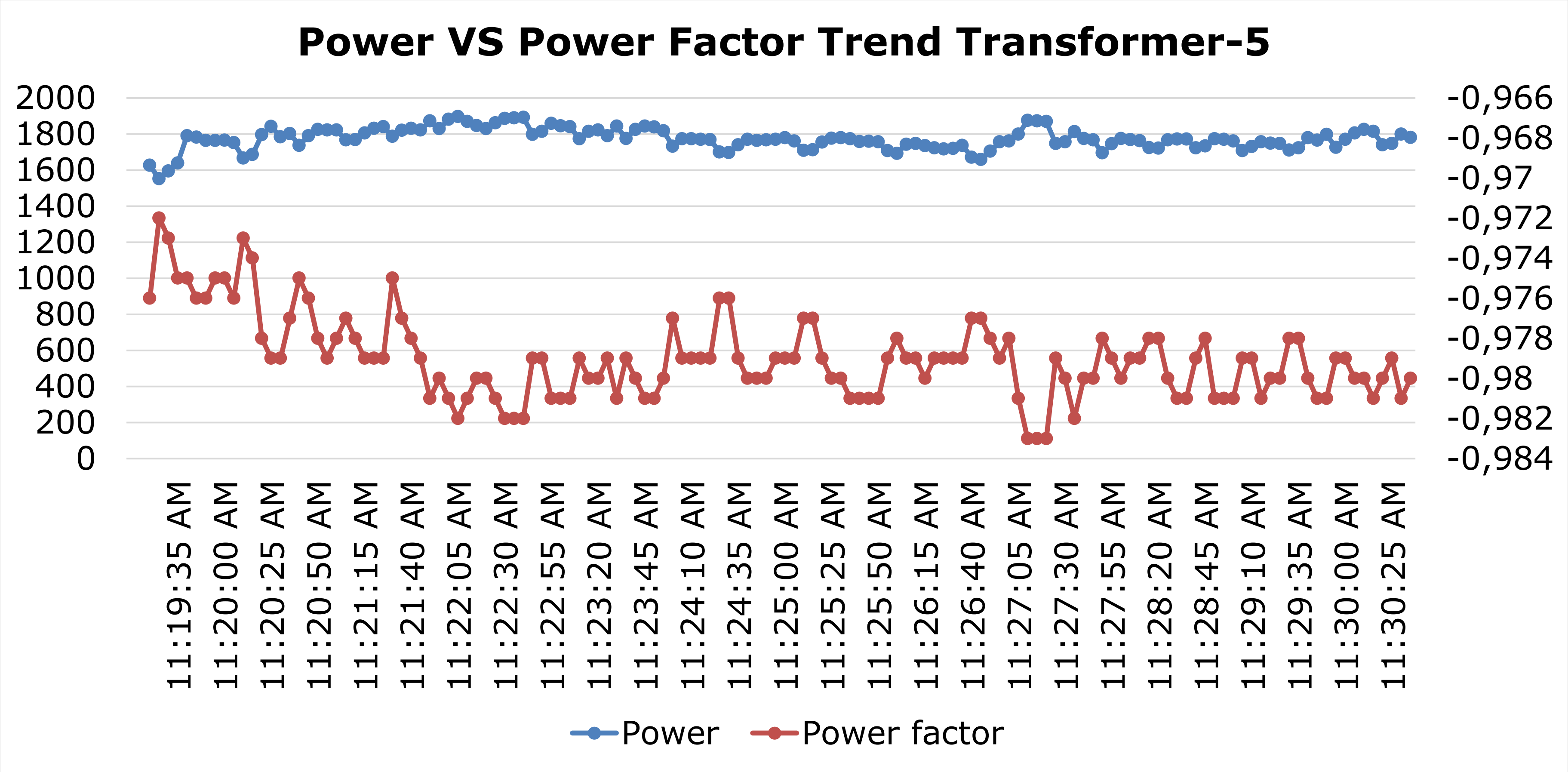

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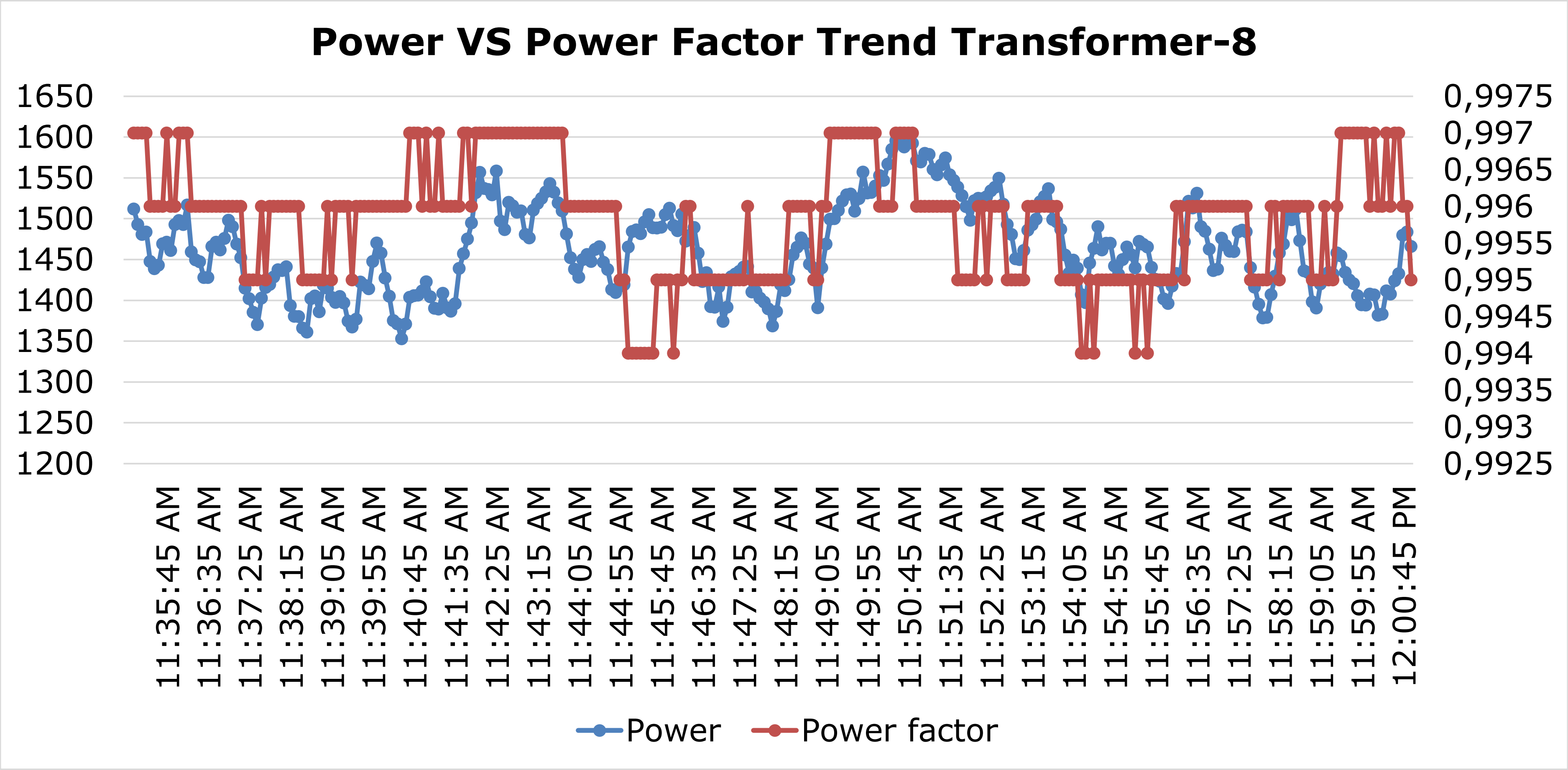

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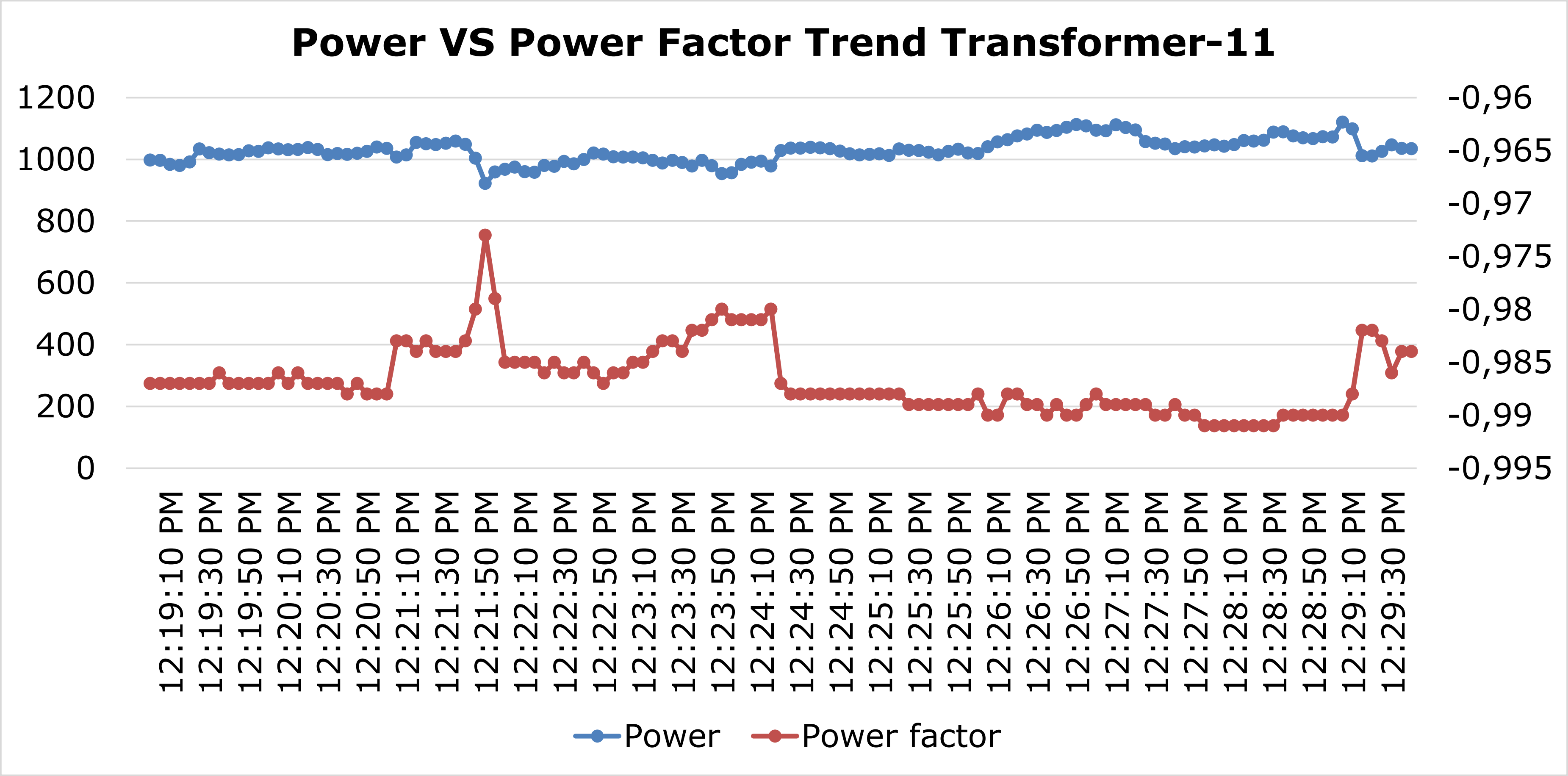

Thank you

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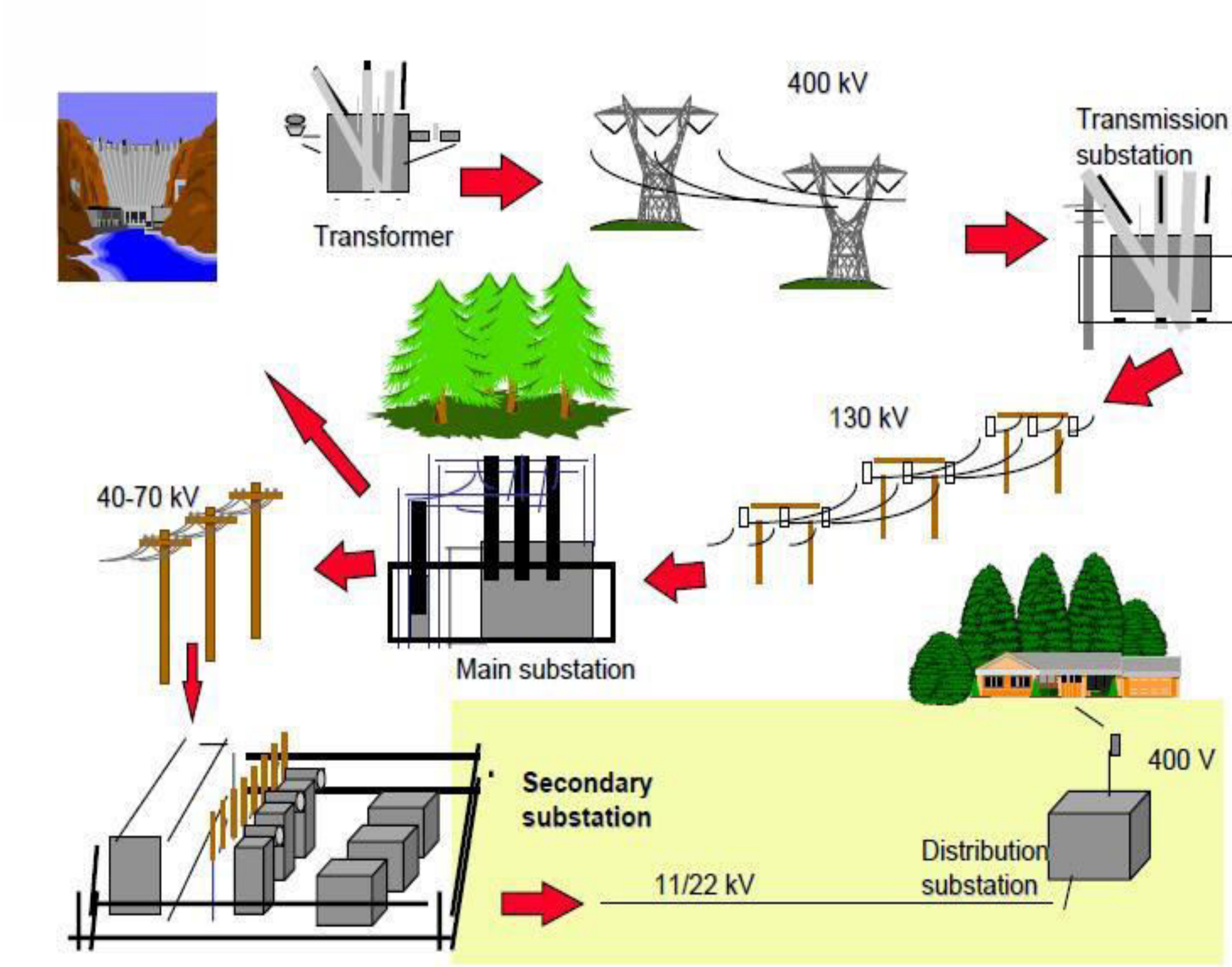
9685613238

Electrical System



Agenda

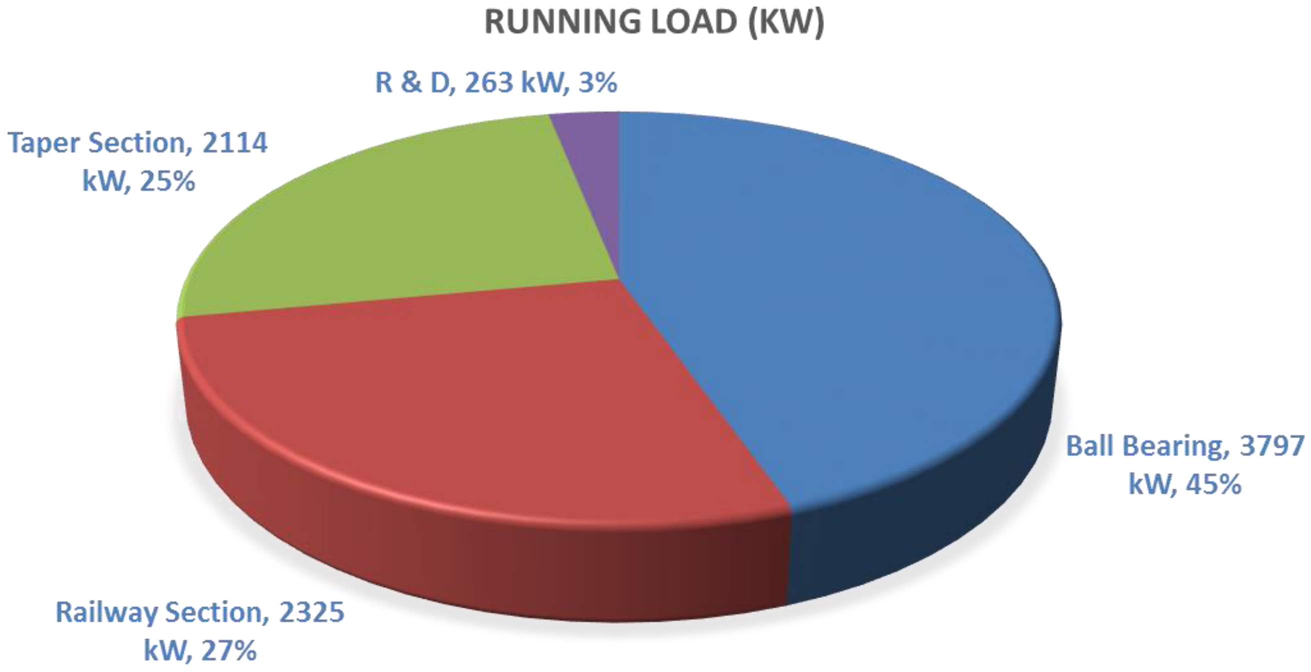
- Introduction – Electrical System
- Major Components
- Electrical System Audit
- Preventive Maintenance benefits
- Role of LSPs

Major Activities

Major activities

- Bill Analysis
- Motor Loading Analysis
- Voltage Drop Study
- Power Factor Analysis
- Thermal Imaging
  - Power Quality / Harmonics Analysis
  - Capacitor Health Check up
  - Earthing / Lux Level
  - Idle Operation

Load Distribution of Plant



Transformer

- **Transformer**
  - Heart of Electrical Distribution
- **Category**
  - Power Transformers
  - Distribution Transformers

Loss in Transformer

- **Efficient Transformer – 1% loss**
    - **Substantial at higher ratings**
- **Losses contributed by**
    - **Core – No load loss**
    - **Copper Loss – Depends on load**

How to Calculate Running Losses

Total losses= No load losses + full load losses x (%age of transformer loading)2

Rating = 2000 kVA
Loading = 1400 kVA
Loading in %age = 70 %
No Load Losses = 3.4 kW
Full Load Losses = 24 kW
Total Losses = 3.4 + 24 (0.7 x 0.7)
= 15.36 kW

Estimation of Losses

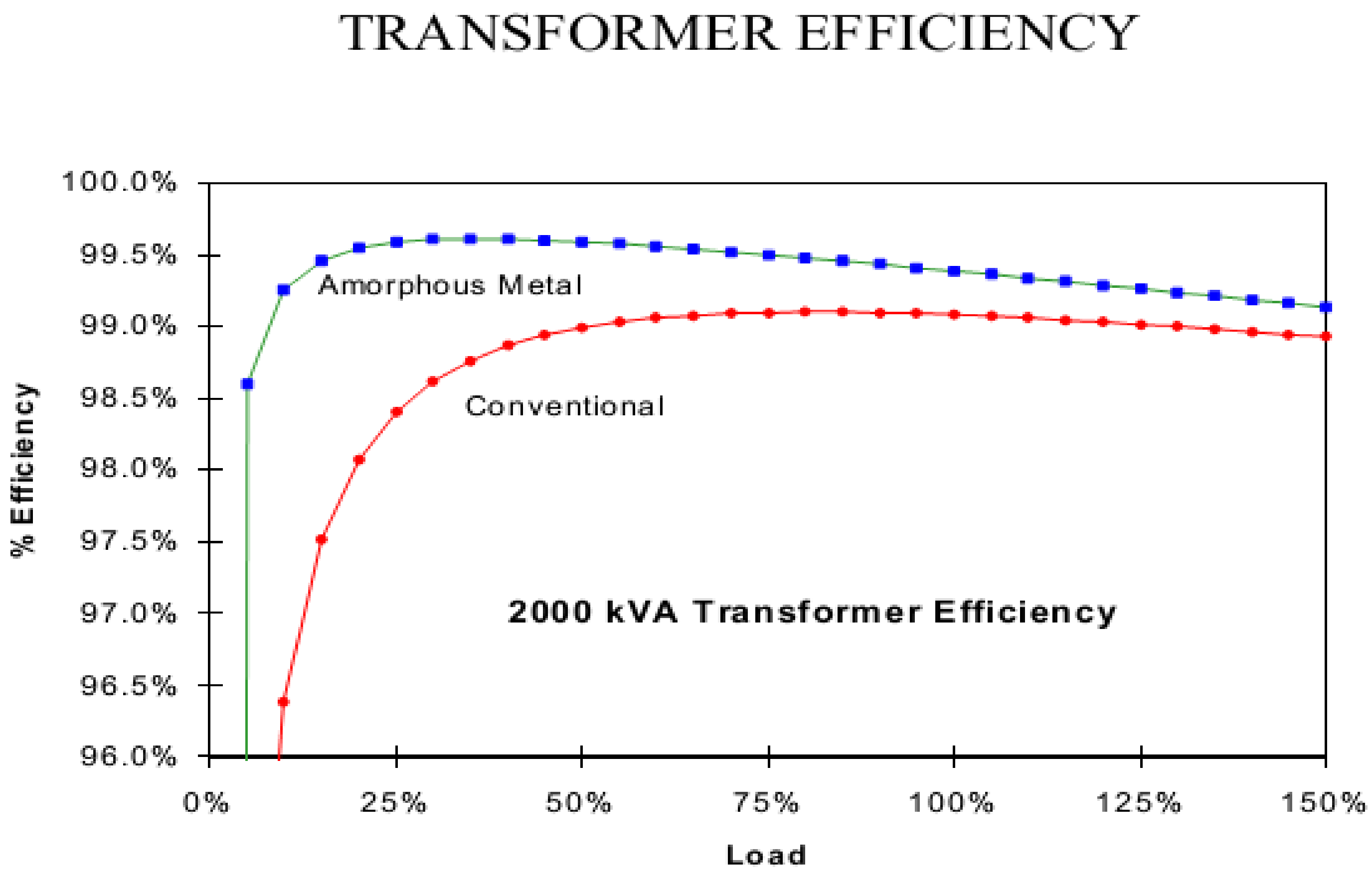
Efficiency >>>98-99 %

- Loss in 1 Transformer = 15.36 kW
- Operational Hours = 8500 Hrs/Yr.
- Power Cost = Rs. 7.0/ Unit
- Cost of Losses = 15.36 x 8500 x 7

  = Rs. 9.15 Lakhs/Yr.

LATEST STANDARD DISTRIBUTION TRANSFORMERS 1180-1 (2014)

Transformer efficiency



MAXIMUM TOTAL LOSSES & IMPEDANCE VALUES UPTO 11 kV CLASS TRANSFORMERS

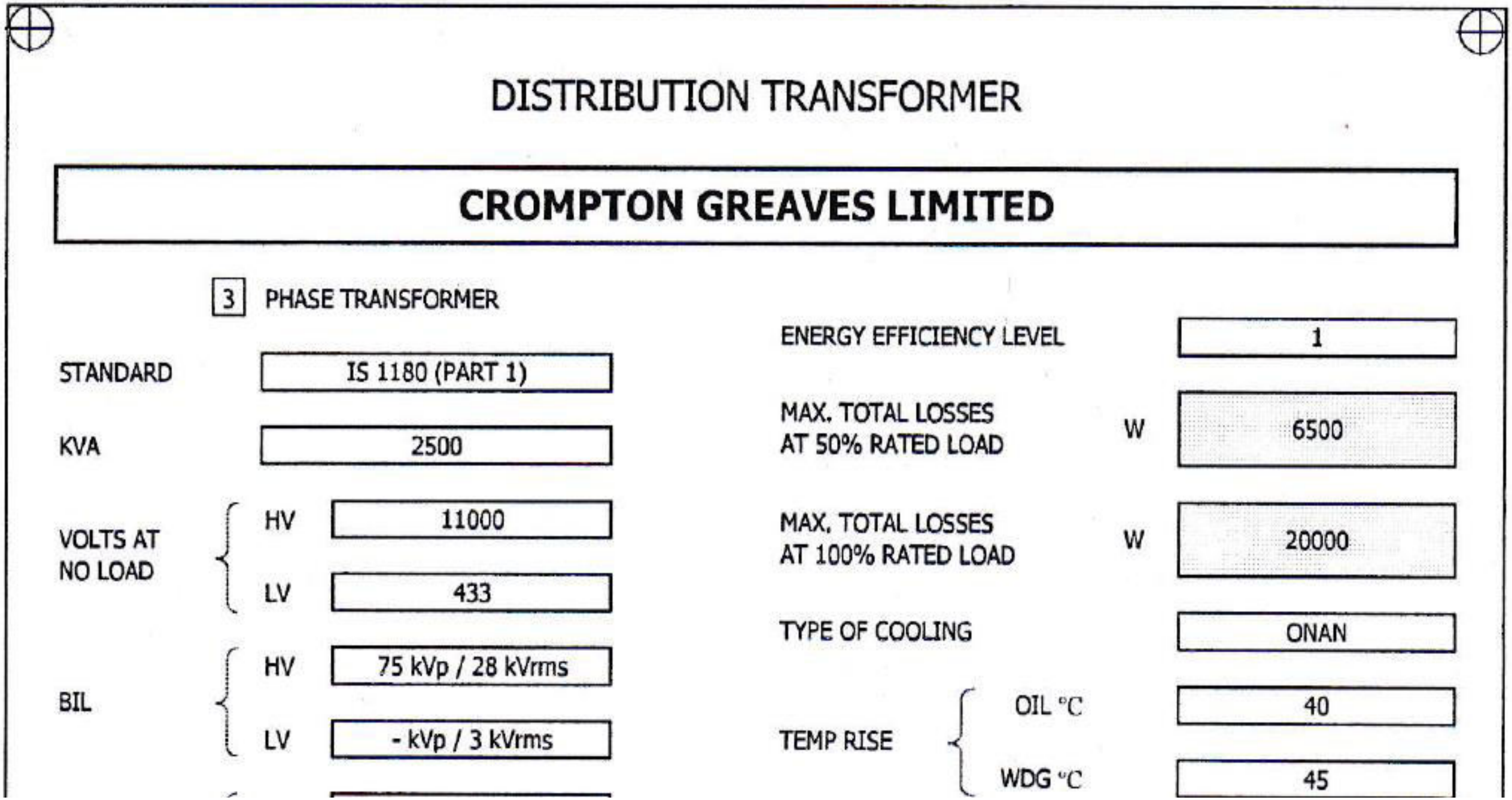
Clauses (7.8.1.1)

S.No	Rating (kVA)	Impedance (percent)	Max. Total Loss (W)					
			Energy Efficiency Level 1		Energy Efficiency Level 2		Energy Efficiency Level 3	
			50 % Load	100 % Load	50 % Load	100 % Load	50 % Load	100 % Load
i	250	4.5	1050	3150	980	2930	920	2700
ii	315	4.5	1100	3275	1025	3100	955	2750
iii	400	4.5	1300	3875	1225	3450	1150	3330
iv	500	4.5	1600	4750	1510	4300	1430	4100
v	630	4.5	2000	5855	1860	5300	1745	4850
vi	1000	5	3000	9000	2790	7700	2620	7000
vii	1250	5	3600	10750	3300	9200	3220	8400
viii	1600	6.25	4500	13500	4200	11800	3970	11300
ix	2000	6.25	5400	17000	5050	15000	4790	14100
x	2500	6.25	6500	20000	6150	18500	5900	17500

MAXIMUM TOTAL LOSSES & IMPEDANCE VALUES UPTO 11 kV CLASS TRANSFORMERS

S.No	Rating (kVA)	Energy Efficiency Level 1		Energy Efficiency Level 2		Energy Efficiency Level 3	
		50 % Load	100 % Load	50 % Load	100 % Load	50 % Load	100 % Load
i	250	99.58 %	98.74 %	99.61 %	98.83 %	99.63 %	98.92 %
ii	315	99.65 %	98.96 %	99.67 %	99.02 %	99.70 %	99.13 %
iii	400	99.68 %	99.03 %	99.69 %	99.14 %	99.71 %	99.17 %
iv	500	99.68 %	99.05 %	99.70 %	99.14 %	99.71 %	99.18 %
v	630	99.68 %	99.07 %	99.70 %	99.16 %	99.72 %	99.23 %
vi	1000	99.70 %	99.10 %	99.72 %	99.23 %	99.74 %	99.30 %
vii	1250	99.71 %	99.14 %	99.74 %	99.26 %	99.74 %	99.33 %
viii	1600	99.72 %	99.16 %	99.74 %	99.26 %	99.75 %	99.29 %
ix	2000	99.73 %	99.15 %	99.75 %	99.25 %	99.76 %	99.30 %
x	2500	99.74 %	99.20 %	99.75 %	99.26 %	99.76 %	99.30 %

Name Plate



DISTRIBUTION TRANSFORMER

CROMPTON GREAVES LIMITED

3 PHASE TRANSFORMER

STANDARD		IS 1180 (PART 1)
KVA		2500
VOLTS AT NO LOAD	HV	11000
	LV	433
BIL	HV	75 kVp / 28 kVrms
	LV	- kVp / 3 kVrms

ENERGY EFFICIENCY LEVEL		1
MAX. TOTAL LOSSES AT 50% RATED LOAD	W	6500
MAX. TOTAL LOSSES AT 100% RATED LOAD	W	20000
TYPE OF COOLING		ONAN
TEMP RISE	OIL °C	40
	WDG °C	45

Case study (New Installation)

Distribution transformer 2500 kVA

% Age impedance 6.25%

Case 1

No load losses	3.8 kW
Load losses	28.0 kW

Case 2 (Level 1 : IS 1180)

No load losses	2.0 kW
Load losses	18.0 kW

Case study

Consider Loading on transformer is 80 %

Total losses= No load losses + full load losses x (%age of transformer loading)2

Case 1

Total Losses = 3.8 + 28 (0.8 x 0.8) = 21.72 kW

Case 2

Total Losses = 2.0 + 18 (0.8 x 0.8) = 13.53 kW

Case study

Total Savings = 21.71 – 13.52 = 8.2 kW

Operational Hours = 8500 hours

Total Energy saving = 8500 x 8.2 = 69700 Units

Unit Rate = Rs. 7.5 Per Unit

Savings = 69700 x 7.5 = Rs. 5.22 Lacs Per Annum

Case study

Cost of Transformer with High Loss = 16 lacs (Approx)

Cost of Transformer with Low Loss = 26 lacs (Approx)

Extra Capital Amount = 10 lacs

Savings = 5.2 lacs/annum

Simple Payback Period = 2 Years

Life of Distribution Transformer = 25 Years

Total savings for Life = 120 Lacs

Maintenance of Transformer

Maintenance Schedule (Hourly)

- Ambient Temperature
- Winding Temperature
- Oil Temperature
- Loading in kVA, Amperes
- Voltage Level (HV /LV)

Maintenance of Transformer

Maintenance of Transformer

Maintenance Schedule (Daily)

- Oil Level in Transformer
  - ✓ Bushings
  - ✓ OLTC
  - ✓ Conservator
- Condition of Breather
- Diaphragm of Explosion Vent
- Cooling fan status

Maintenance of Transformer

Maintenance Schedule (Quarterly)

- Oil Dielectric Strength (>40 kV)
  - ✓ BDV
  - ✓ Water Content
- Condition of Bushings
- Dehydration of Oil if required

Maintenance of Transformer

Maintenance Schedule (Half Yearly)

- ➢ Oil Dielectric Strength (>40 kV)
  - ✓ BDV
  - ✓ Water Content
- ➢ DGA Test (Dissolved Gas Analysis)
- ➢ OLTC Operation checking
- ➢ Dehydration of Oil if required

Maintenance of Transformer

Maintenance Schedule (Yearly)

- Oil Dielectric Strength (>40 kV)
  - ✓ BDV
  - ✓ Water Content
  - ✓ DGA Test (Dissolved Gas Analysis)
- OLTC Operation checking
- Condition of Bushings
- Dehydration of Oil

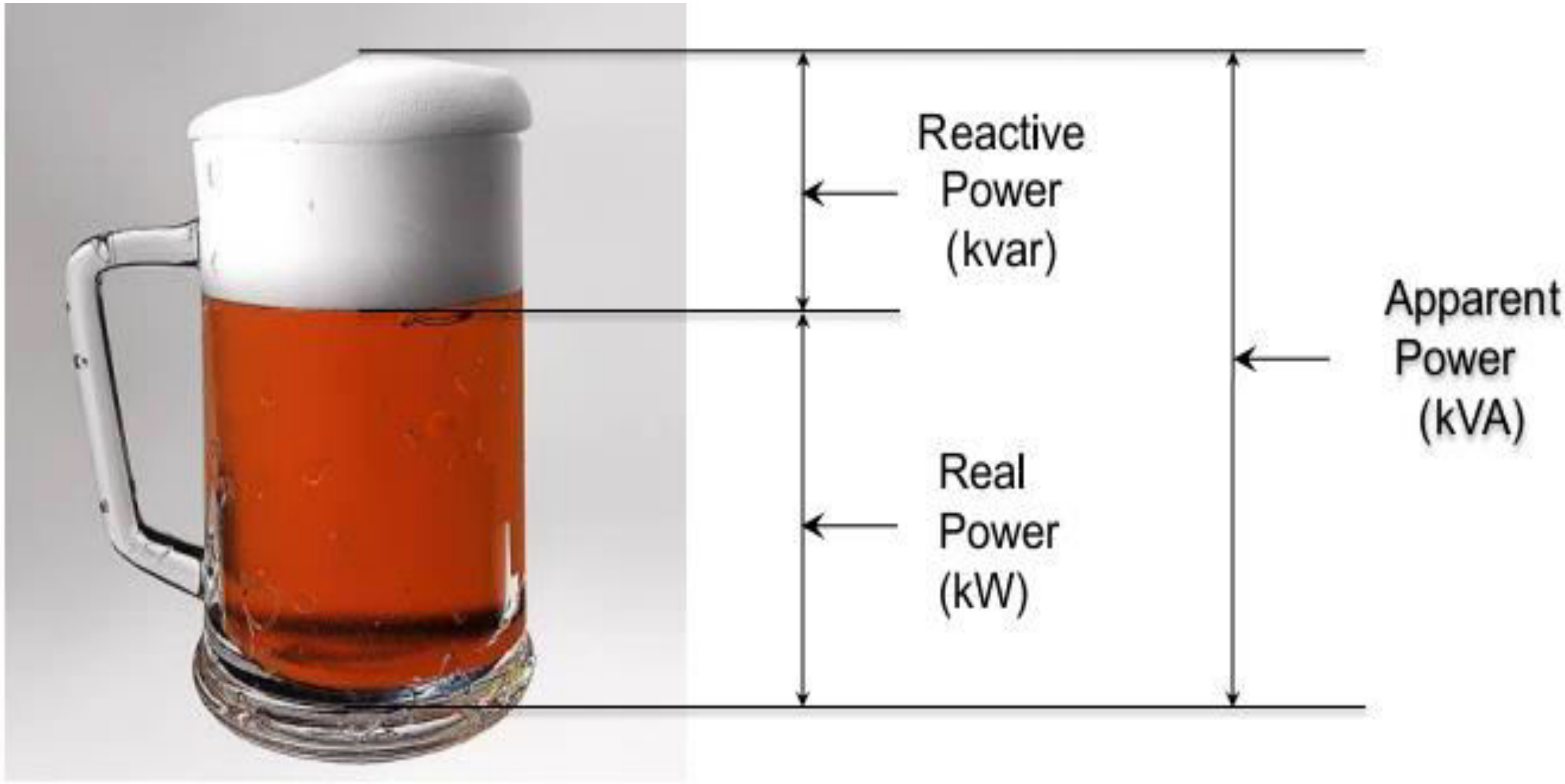
Maintenance of Transformer

Maintenance Schedule (Yearly)

- Checking of all Nut & Bolts
- Gasket Joints
- Cable/Bus bar Boxes
- Relay/alarm Circuits
- Painting
- Sludge Checking
- Wash Core with Oil if sludge is more

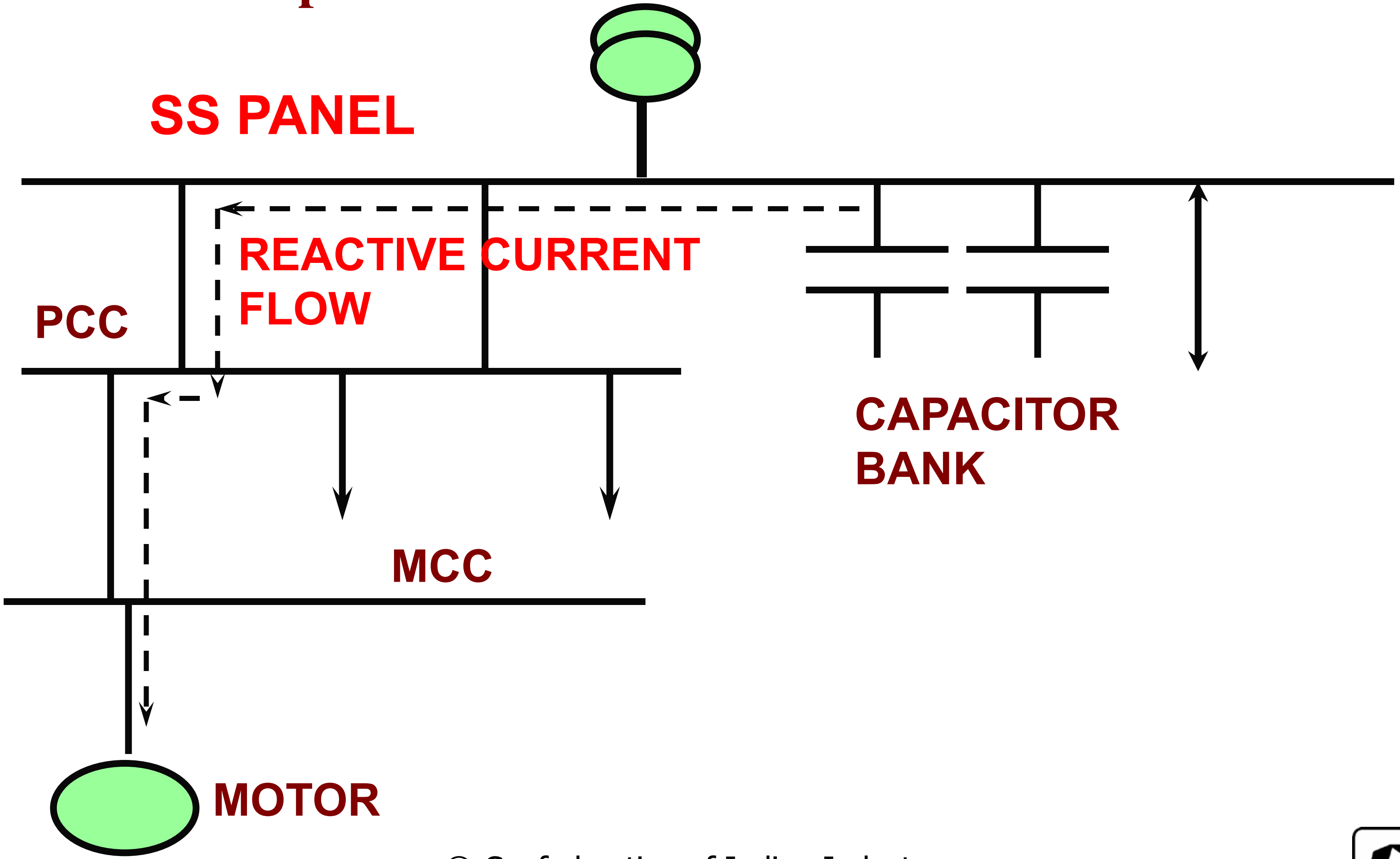
Analogy

$$\text{Power factor} = \frac{\text{kW}}{\text{KVA}} = \frac{\text{kW}}{\text{kW} + \text{KVAr}} = \frac{\text{Beer}}{\text{Beer + Foam}}$$



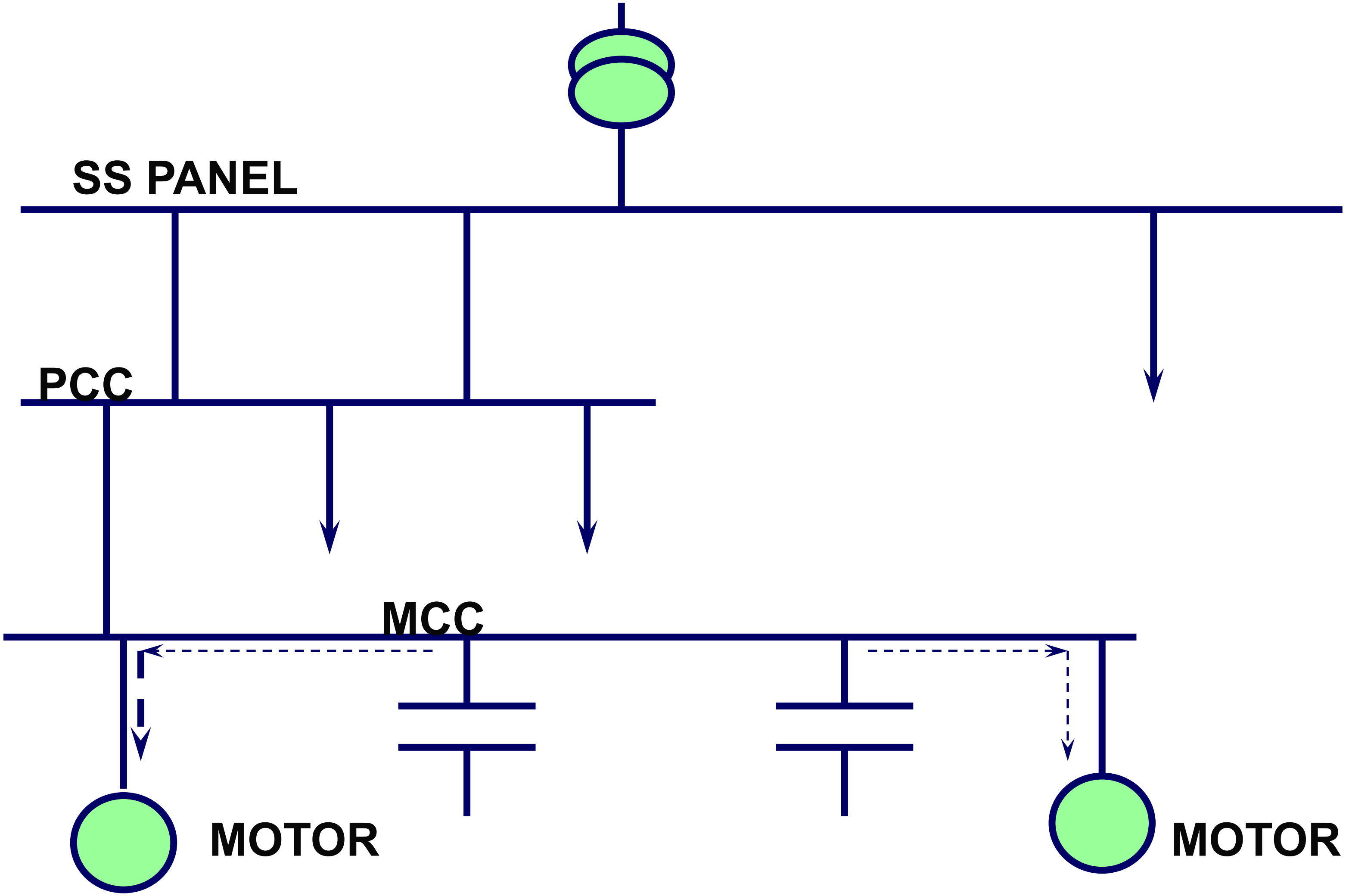
PF COMPENSATION

Centralized compensation



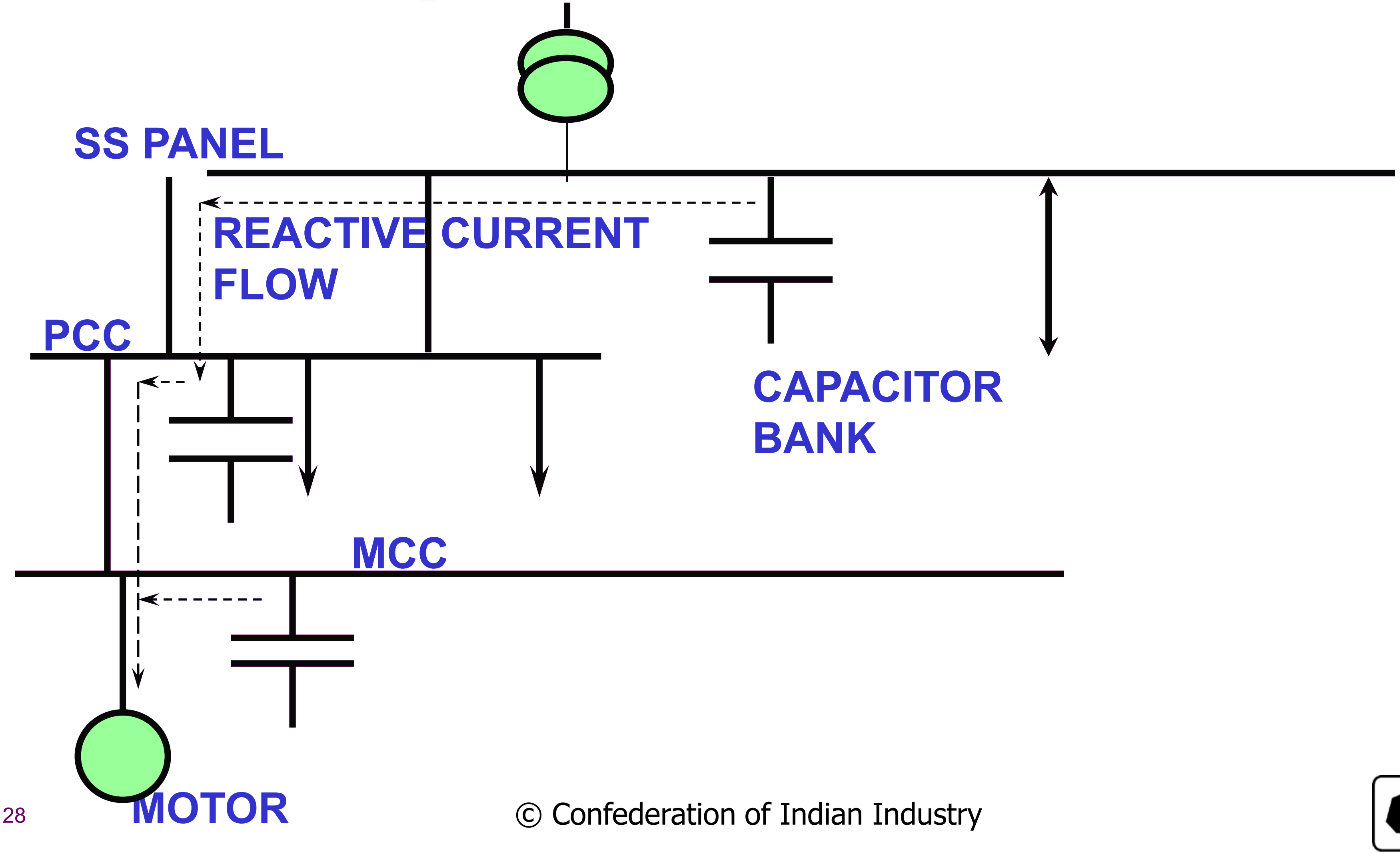
PF COMPENSATION

Distributed Compensation



PF COMPENSATION

Mixed Compensation



Electricity Tariff Details

Punjab State Revised

Punjab State is having Single Discom

- Punjab State Power Corporation Limited

Billing is in kVAh

Billing Structure		Fixed Charges (₹)	Energy Charges (₹)
General Industry	Above 100 kVA & upto 1000 kVA	140/kVA	5.70/kVAh
	Above 100 kVA & upto 2500 kVA	195/kVA	5.74/kVAh
	Above 2500 KVA	230/kVA	5.78/kVAh
PIU / ARC Furnace	Above 100 kVA & upto 1000 kVA	160/kVA	5.74/kVAh
	Above 1000 KVA	295/kVA	5.98/kVAh
Bulk Supply	LT	155/kVA	6.25/kVAh
	HT	195/kVA	5.85/kVAh

Punjab State Revised

Voltage Rebate

- Rebate of 30 paise/kVAh to all consumers getting supply at 400/220/132 kV, 25 paise/kVAh to all consumers getting supply at 66/33 kV, 20 paise/kVAh to DS, NRS & MS consumers getting supply at 11 kV

Bill Analysis

Present System

- Bill analysis done in detail
- Power factor, MDI, Energy consumption, studied in detail
- Present Billing is in kVAh
- Present CD – 400 kVA

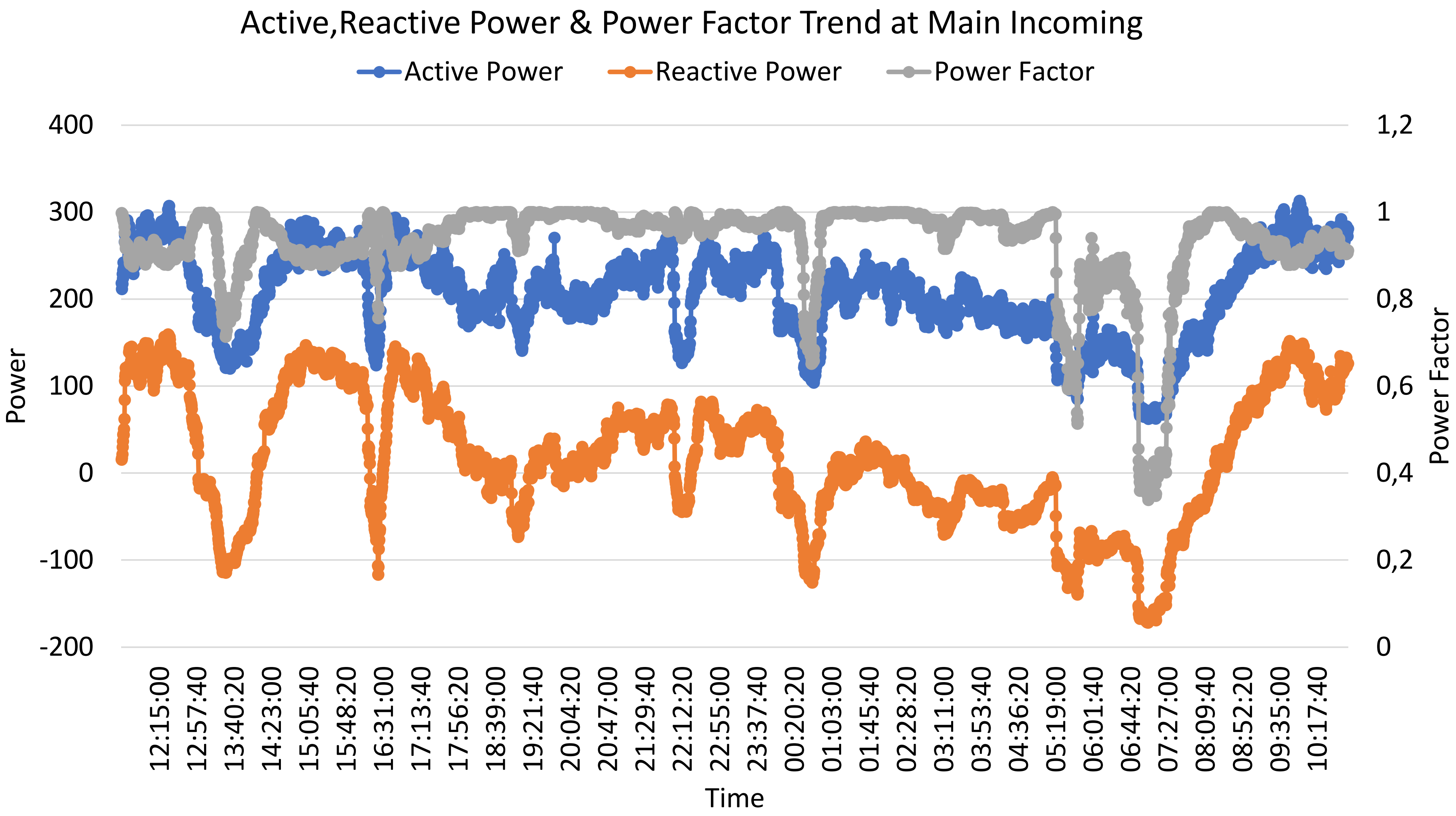
Bill Analysis Power Factor

Month	Energy Consumption kVAh	Energy Consumption kWh	Power Factor	Energy charges in Rs.	Monthly E Bill Rs.	P.F Unit Cost Rs.
Jan-17	123268	116184	0.943	706746	846760	5.7
Feb-17	110308	104639	0.949	635074	760890	5.8
Mar-17	118743	111194	0.936	678301	812730	5.7
Apr-17	141689	131209	0.926	812238	939330	5.7
May-17	145736	134312	0.922	834454	1011619	5.7
Jun-17	166454	152546	0.916	956093	1162370	5.7
Jul-17	145121	133649	0.921	922256	1116900	6.4
Aug-17	158618	143177	0.903	1004051	1206280	6.3
Sep-17	173950	154323	0.887	1099847	1349100	6.3
Oct-17	183444	158524	0.864	1165479	1436280	6.4
Nov-17	185735	163825	0.882	1069120	1310929	5.8
Dec-17	160515	146277	0.911	990189	1199910	6.2
	1813581	1649859	0.913	10873848	13153098	6.0

Bill Analysis

Month	Contract Demand in kVA	Actual Demand in kVA	Fine Demand charges in RS	Rs/kVA	Monthly Bill	unit Cost
Jan-17	400	321		0	846760	6.87
Feb-17	400	351		0	760890	6.90
Mar-17	400	364		0	812730	6.84
Apr-17	400	394		0	939330	6.63
May-17	400	405.36	4020	750	1011619	6.94
Jun-17	400	422.76	17070	750	1162370	6.98
Jul-17	400	418.2	13650	750	1116900	7.70
Aug-17	400	428.04	21030	750	1206280	7.60
Sep-17	400	467.76	50820	750	1349100	7.76
Oct-17	400	480.73	60540	750	1436280	7.83
Nov-17	400	465.1	48840	750	1310929	7.06
Dec-17	400	441.36	31020	750	1199910	7.48
			246990		13153098	7.22

Analysis of Electrical Parameters on Main Incoming



Capacitor Bank

Capacitor Bank Health Check-up						
Name	Rated kVAR	Actual kVAr	Measured Current in Amperes			Measured kVAr
	440 Volts	396 kVAr	R	Y	B	
1	25	21.7	31.1	30.5	31.4	21.51
2	25	21.7	30.7	31.5	31.3	21.62
3	10	8.7	0.8	4.5	0.0	1.23
4	20	17.4	24.1	25.2	24.7	17.11
5	20	17.4	24.5	25.4	24.2	17.13
6	25	21.7	31.3	31.3	30.3	21.48
7	10	8.7	0.0	0.0	0.0	0.00
8	25	21.7	31.7	24.1	23.6	18.36
9	25	21.7	54.5	23.1	30.7	-

Improve Overall Power factor of Plant

Concern Point

- No APFC panel is Installed
- Capacitors are manually connected
- No Control on reactive power supply
- Connected Capacitors are not sufficient to maintain unity power factor

Improve Overall Power factor of Plant

Action Plan

- Install new APFC of 400 kVAr
- isolate Manual Capacitors
- Maintain Unity Power Factor at SEB Meter
- Install MDI Controller and maintain MDI at 395 kVA
- Shut of Non critical load if MDI crosses 395 kVA

Saving Potential

Month	Energy Consumption kVAh	Energy Consumption kWh	Power Factor	Energy charges	Monthly Bill	P.F Unit Cost	Saving Potential
Jan-17	123268	116184	0.943	706746	846760	5.7	40615
Feb-17	110308	104639	0.949	635074	760890	5.8	32638
Mar-17	118743	111194	0.936	678301	812730	5.7	43122
Apr-17	141689	131209	0.926	812238	939330	5.7	60077
May-17	145736	134312	0.922	834454	1011619	5.7	65411
Jun-17	166454	152546	0.916	956093	1162370	5.7	79886
Jul-17	145121	133649	0.921	922256	1116900	6.4	72906
Aug-17	158618	143177	0.903	1004051	1206280	6.3	97741
Sep-17	173950	154323	0.887	1099847	1349100	6.3	124097
Oct-17	183444	158524	0.864	1165479	1436280	6.4	158325
Nov-17	185735	163825	0.882	1069120	1310929	5.8	126117
Dec-17	160515	146277	0.911	990189	1199910	6.2	87832
	1813581	1649859	0.9133	10873848	13153098	6.0	9.89

Improve Overall Power factor of Plant

Annual Savings	- Rs 12.35 Lakhs
Investment	- Rs 4.0 Lakhs
Payback	- 4 Months

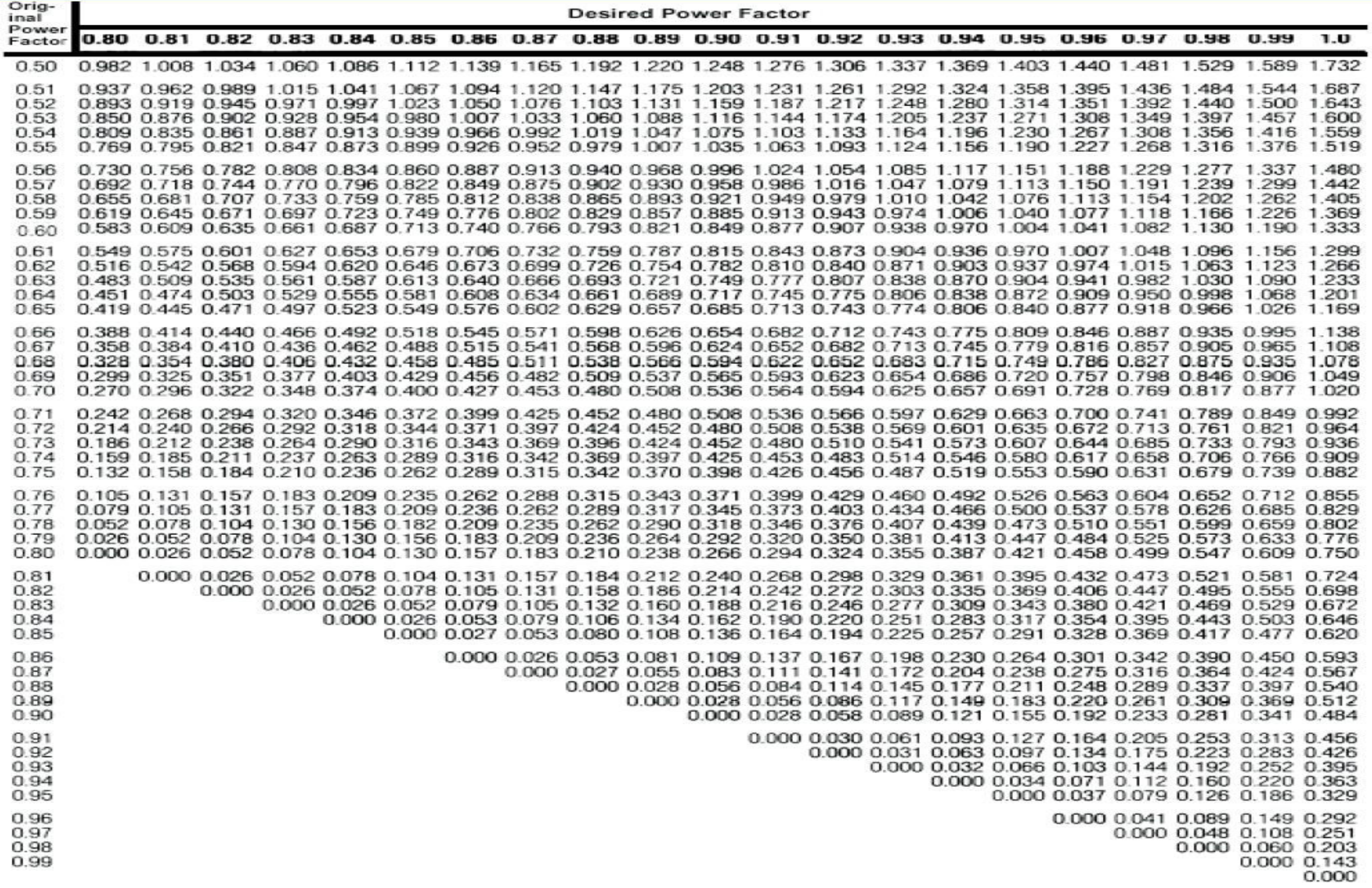
Capacitor Selection

- **Chart Method**
- **Formula Method**

- **Capacitor required (KVAr)**

  = kW x {Tan cos-1Φ1 – Tan cos-1Φ2 }
- **Cos Φ1 – Present power factor**
- **Cos Φ2 – Desired power factor**

TABLE 1.2 MULTIPLIERS TO DETERMINE CAPACITOR kVAr REQUIREMENTS FOR POWER FACTOR CORRECTION



Original Power Factor	Desired Power Factor																				
	0.80	0.81	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	1.0
0.50	0.982	1.008	1.034	1.060	1.086	1.112	1.139	1.165	1.192	1.220	1.248	1.276	1.306	1.337	1.369	1.403	1.440	1.481	1.529	1.589	1.732
0.51	0.937	0.962	0.989	1.015	1.041	1.067	1.094	1.120	1.147	1.175	1.203	1.231	1.261	1.292	1.324	1.358	1.395	1.436	1.484	1.544	1.687
0.52	0.893	0.919	0.945	0.971	0.997	1.023	1.050	1.076	1.103	1.131	1.159	1.187	1.217	1.248	1.280	1.314	1.351	1.392	1.440	1.500	1.643
0.53	0.850	0.876	0.902	0.928	0.954	0.980	1.007	1.033	1.060	1.088	1.116	1.144	1.174	1.205	1.237	1.271	1.308	1.349	1.397	1.457	1.600
0.54	0.809	0.835	0.861	0.887	0.913	0.939	0.966	0.992	1.019	1.047	1.075	1.103	1.133	1.164	1.196	1.230	1.267	1.308	1.356	1.416	1.559
0.55	0.769	0.795	0.821	0.847	0.873	0.899	0.926	0.952	0.979	1.007	1.035	1.063	1.093	1.124	1.156	1.190	1.227	1.268	1.316	1.376	1.519
0.56	0.730	0.756	0.782	0.808	0.834	0.860	0.887	0.913	0.940	0.968	0.996	1.024	1.054	1.085	1.117	1.151	1.188	1.229	1.277	1.337	1.480
0.57	0.692	0.718	0.744	0.770	0.796	0.822	0.849	0.875	0.902	0.930	0.958	0.986	1.016	1.047	1.079	1.113	1.150	1.191	1.239	1.299	1.442
0.58	0.655	0.681	0.707	0.733	0.759	0.785	0.812	0.838	0.865	0.893	0.921	0.949	0.979	1.010	1.042	1.076	1.113	1.154	1.202	1.262	1.405
0.59	0.619	0.645	0.671	0.697	0.723	0.749	0.776	0.802	0.829	0.857	0.885	0.913	0.943	0.974	1.006	1.040	1.077	1.118	1.166	1.226	1.369
0.60	0.583	0.609	0.635	0.661	0.687	0.713	0.740	0.766	0.793	0.821	0.849	0.877	0.907	0.938	0.970	1.004	1.041	1.082	1.130	1.190	1.333
0.61	0.549	0.575	0.601	0.627	0.653	0.679	0.706	0.732	0.759	0.787	0.815	0.843	0.873	0.904	0.936	0.970	1.007	1.048	1.096	1.156	1.299
0.62	0.516	0.542	0.568	0.594	0.620	0.646	0.673	0.699	0.726	0.754	0.782	0.810	0.840	0.871	0.903	0.937	0.974	1.015	1.063	1.123	1.266
0.63	0.483	0.509	0.535	0.561	0.587	0.613	0.640	0.666	0.693	0.721	0.749	0.777	0.807	0.838	0.870	0.904	0.941	0.982	1.030	1.090	1.233
0.64	0.451	0.474	0.503	0.529	0.555	0.581	0.608	0.634	0.661	0.689	0.717	0.745	0.775	0.806	0.838	0.872	0.909	0.950	0.998	1.068	1.201
0.65	0.419	0.445	0.471	0.497	0.523	0.549	0.576	0.602	0.629	0.657	0.685	0.713	0.743	0.774	0.806	0.840	0.877	0.918	0.966	1.026	1.169
0.66	0.388	0.414	0.440	0.466	0.492	0.518	0.545	0.571	0.598	0.626	0.654	0.682	0.712	0.743	0.775	0.809	0.846	0.887	0.935	0.995	1.138
0.67	0.358	0.384	0.410	0.436	0.462	0.488	0.515	0.541	0.568	0.596	0.624	0.652	0.682	0.713	0.745	0.779	0.816	0.857	0.905	0.965	1.108
0.68	0.328	0.354	0.380	0.406	0.432	0.458	0.485	0.511	0.538	0.566	0.594	0.622	0.652	0.683	0.715	0.749	0.786	0.827	0.875	0.935	1.078
0.69	0.299	0.325	0.351	0.377	0.403	0.429	0.456	0.482	0.509	0.537	0.565	0.593	0.623	0.654	0.686	0.720	0.757	0.798	0.846	0.906	1.049
0.70	0.270	0.296	0.322	0.348	0.374	0.400	0.427	0.453	0.480	0.508	0.536	0.564	0.594	0.625	0.657	0.691	0.728	0.769	0.817	0.877	1.020
0.71	0.242	0.268	0.294	0.320	0.346	0.372	0.399	0.425	0.452	0.480	0.508	0.536	0.566	0.597	0.629	0.663	0.700	0.741	0.789	0.849	0.992
0.72	0.214	0.240	0.266	0.292	0.318	0.344	0.371	0.397	0.424	0.452	0.480	0.508	0.538	0.569	0.601	0.635	0.672	0.713	0.761	0.821	0.964
0.73	0.186	0.212	0.238	0.264	0.290	0.316	0.343	0.369	0.396	0.424	0.452	0.480	0.510	0.541	0.573	0.607	0.644	0.685	0.733	0.793	0.936
0.74	0.159	0.185	0.211	0.237	0.263	0.289	0.316	0.342	0.369	0.397	0.425	0.453	0.483	0.514	0.546	0.580	0.617	0.658	0.706	0.766	0.909
0.75	0.132	0.158	0.184	0.210	0.236	0.262	0.289	0.315	0.342	0.370	0.398	0.426	0.456	0.487	0.519	0.553	0.590	0.631	0.679	0.739	0.882
0.76	0.105	0.131	0.157	0.183	0.209	0.235	0.262	0.288	0.315	0.343	0.371	0.399	0.429	0.460	0.492	0.526	0.563	0.604	0.652	0.712	0.855
0.77	0.079	0.105	0.131	0.157	0.183	0.209	0.236	0.262	0.289	0.317	0.345	0.373	0.403	0.434	0.466	0.500	0.537	0.578	0.626	0.685	0.829
0.78	0.052	0.078	0.104	0.130	0.156	0.182	0.209	0.235	0.262	0.290	0.318	0.346	0.376	0.407	0.439	0.473	0.510	0.551	0.599	0.659	0.802
0.79	0.026	0.052	0.078	0.104	0.130	0.156	0.183	0.209	0.236	0.264	0.292	0.320	0.350	0.381	0.413	0.447	0.484	0.525	0.573	0.633	0.776
0.80	0.000	0.026	0.052	0.078	0.104	0.130	0.157	0.183	0.210	0.238	0.266	0.294	0.324	0.355	0.387	0.421	0.458	0.499	0.547	0.609	0.750
0.81		0.000	0.026	0.052	0.078	0.104	0.131	0.157	0.184	0.212	0.240	0.268	0.298	0.329	0.361	0.395	0.432	0.473	0.521	0.581	0.724
0.82			0.000	0.026	0.052	0.078	0.105	0.131	0.158	0.186	0.214	0.242	0.272	0.303	0.335	0.369	0.406	0.447	0.495	0.555	0.698
0.83				0.000	0.026	0.052	0.079	0.105	0.132	0.160	0.188	0.216	0.246	0.277	0.309	0.343	0.380	0.421	0.469	0.529	0.672
0.84					0.000	0.026	0.053	0.079	0.106	0.134	0.162	0.190	0.220	0.251	0.283	0.317	0.354	0.395	0.443	0.503	0.646
0.85						0.000	0.027	0.053	0.080	0.108	0.136	0.164	0.194	0.225	0.257	0.291	0.328	0.369	0.417	0.477	0.620
0.86							0.000	0.026	0.053	0.081	0.109	0.137	0.167	0.198	0.230	0.264	0.301	0.342	0.390	0.450	0.593
0.87								0.000	0.027	0.055	0.083	0.111	0.141	0.172	0.204	0.238	0.275	0.316	0.364	0.424	0.567
0.88									0.000	0.028	0.056	0.084	0.114	0.145	0.177	0.211	0.248	0.289	0.337	0.397	0.540
0.89										0.000	0.028	0.056	0.086	0.117	0.149	0.183	0.220	0.261	0.309	0.369	0.512
0.90											0.000	0.028	0.058	0.089	0.121	0.155	0.192	0.233	0.281	0.341	0.484
0.91												0.000	0.030	0.061	0.093	0.127	0.164	0.205	0.253	0.313	0.456
0.92													0.000	0.031	0.063	0.097	0.134	0.175	0.223	0.283	0.426
0.93														0.000	0.032	0.066	0.103	0.144	0.192	0.252	0.395
0.94															0.000	0.034	0.071	0.112	0.160	0.220	0.363
0.95																0.000	0.037	0.079	0.126	0.186	0.329
0.96																	0.000	0.041	0.089	0.149	0.292
0.97																		0.000	0.048	0.108	0.251
0.98																			0.000	0.060	0.203
0.99																				0.000	0.143
																					0.000

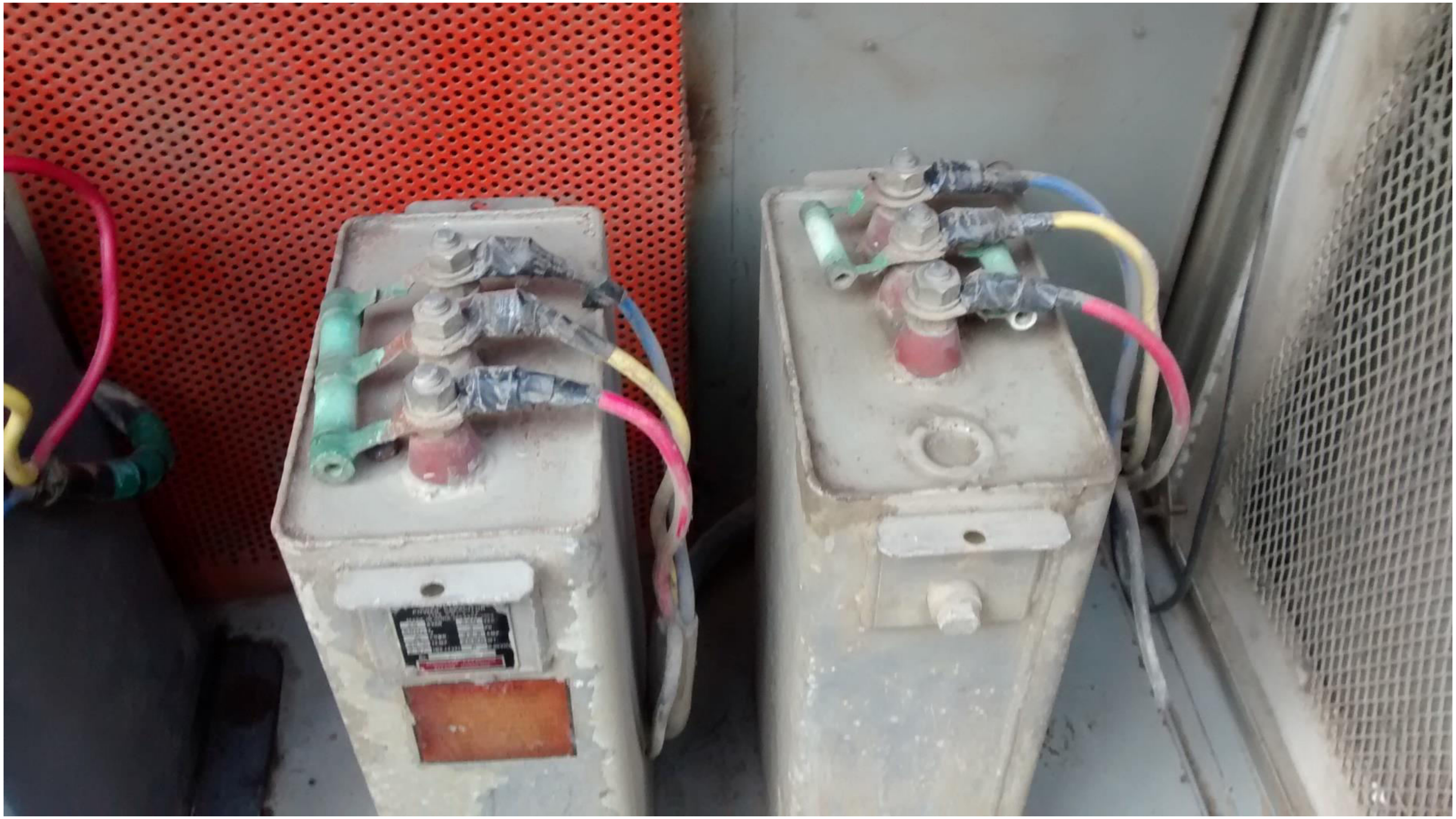
Power Capacitors

- Capacitor banks install to improve power factor

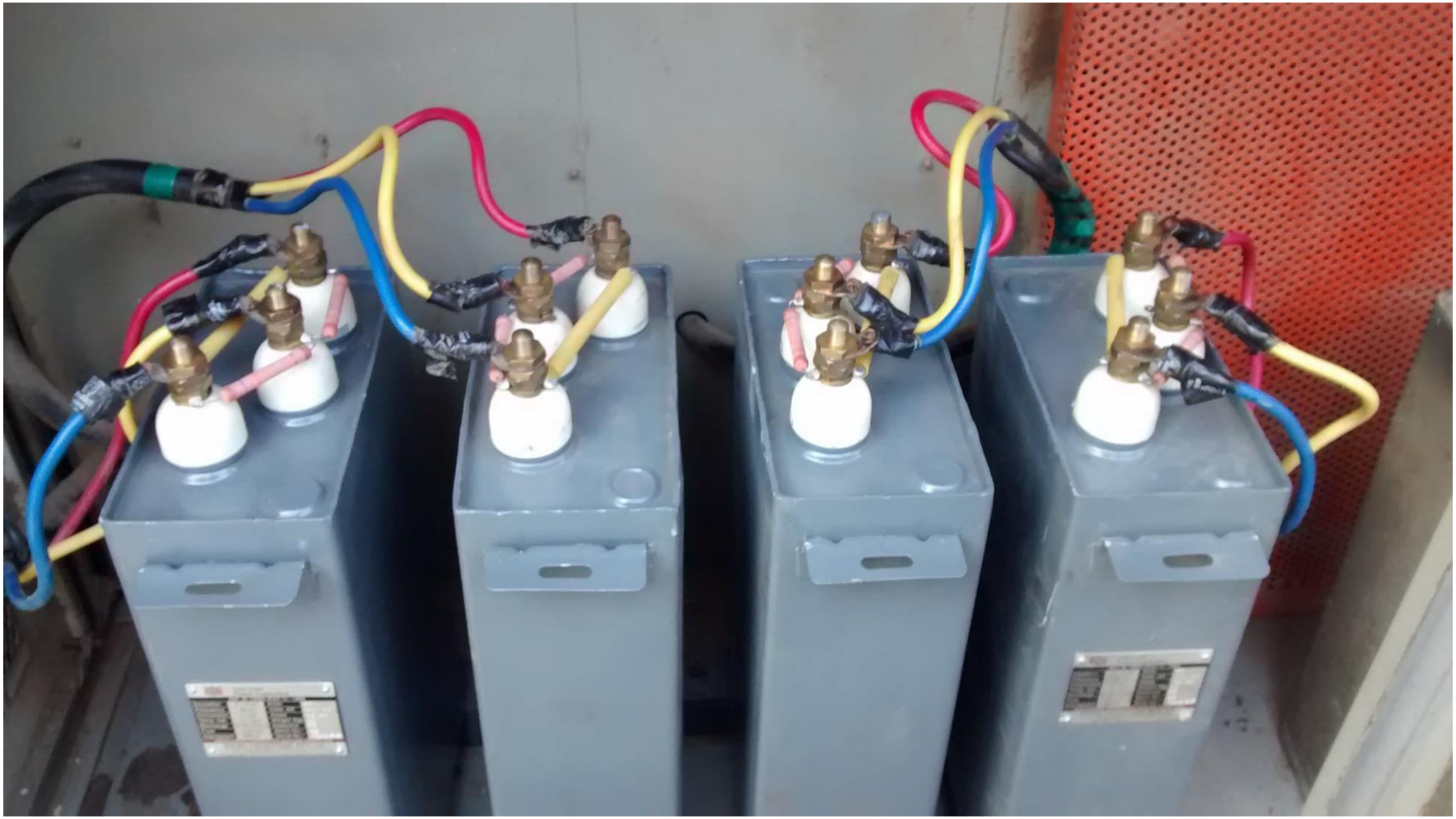
Reasons for failure

- Ageing
- Input voltage and frequency fluctuation
- Harmonics present in the system
- Temperature around the bank
- Poor quality capacitors use in the construction

Power Capacitors



Power Capacitors



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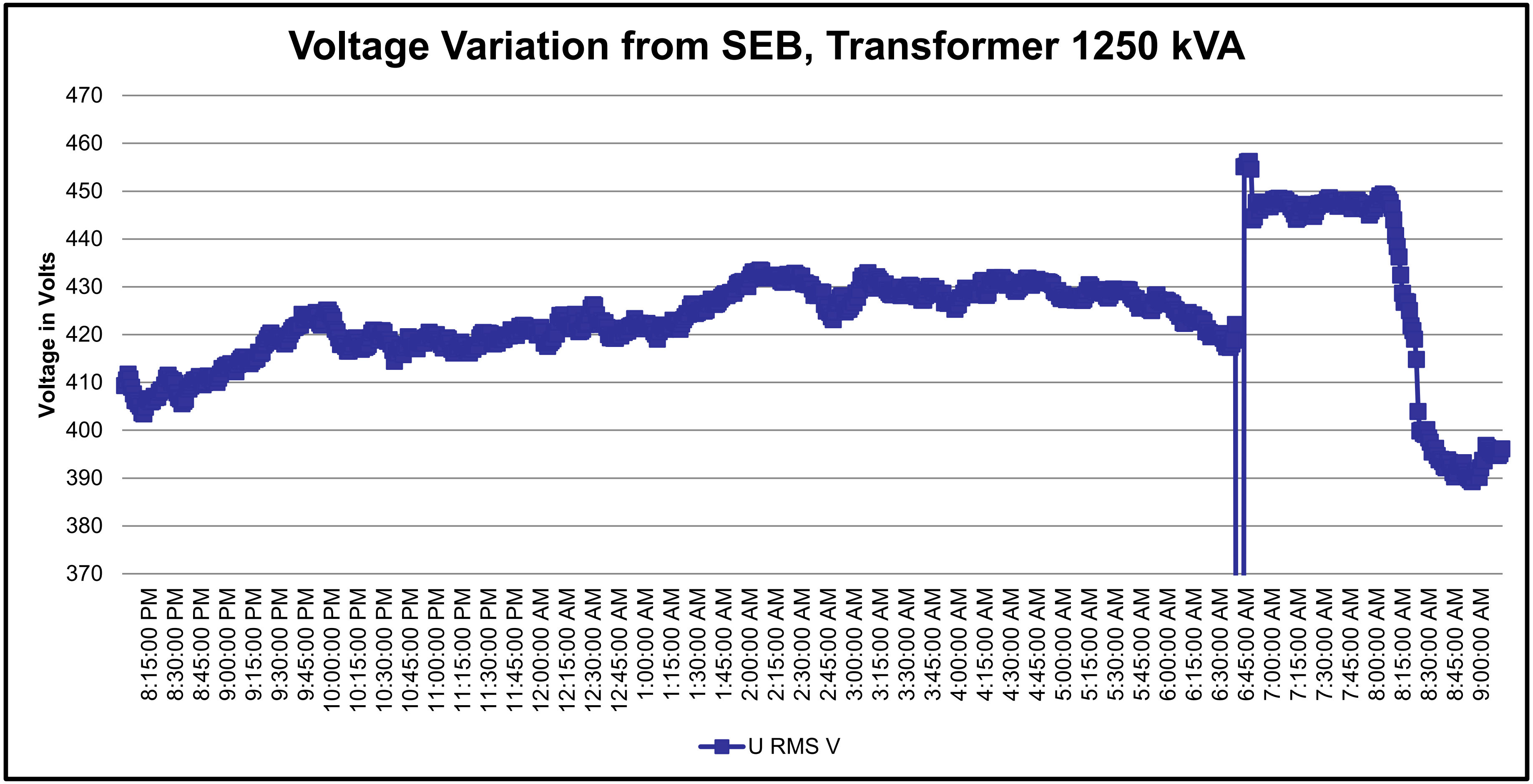
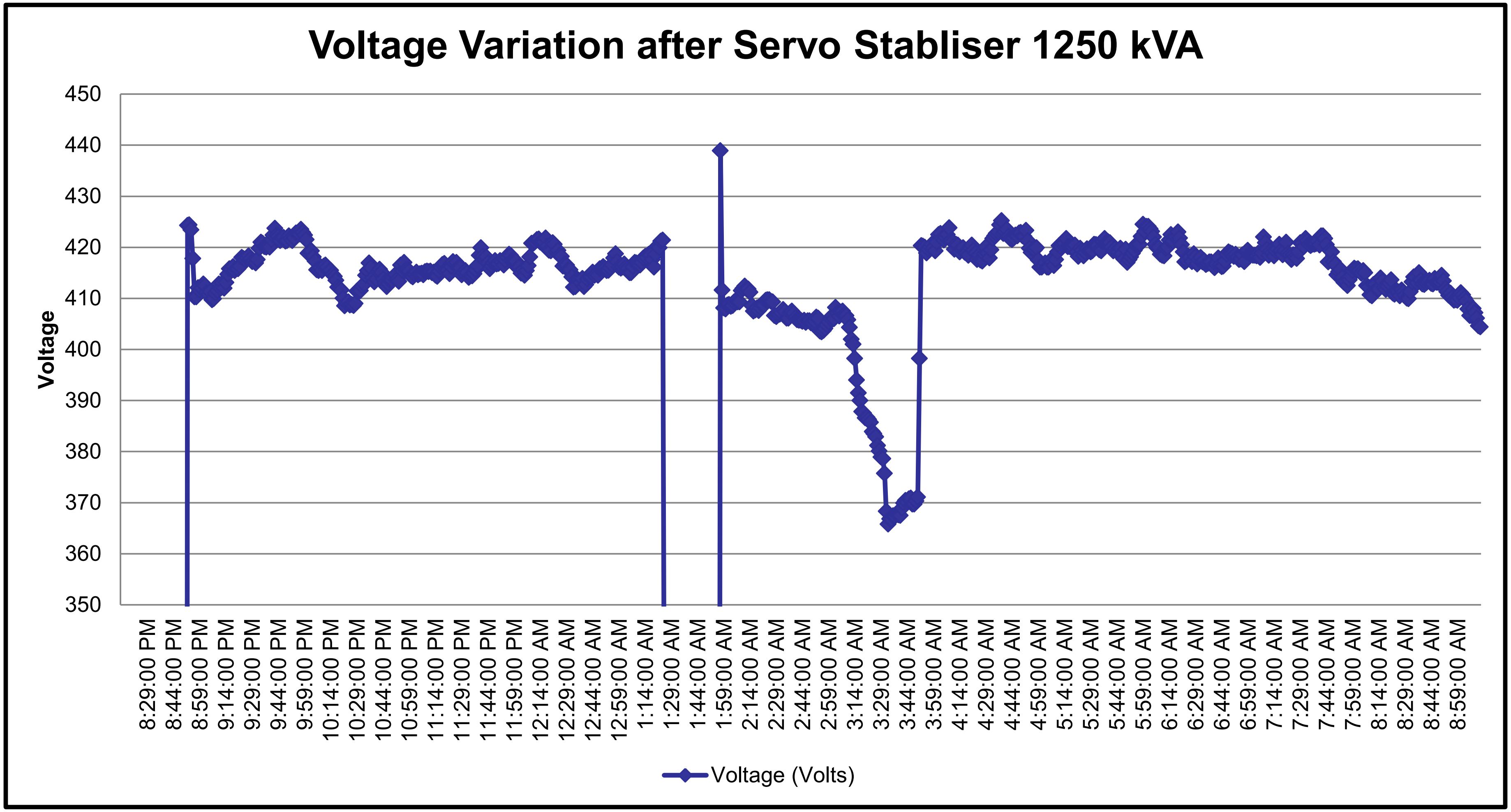
OPTIMIZE PLANT VOLTAGE AT 415 V

- Transformer 1250 kVA and 800 kVA, with Off Load Tap Changer
- Both Transformers are installed with Servo - Stabilizers
- Voltage pattern analyzed
  - Data Logger installed on plant transformer and servo stabilizers– recordings done

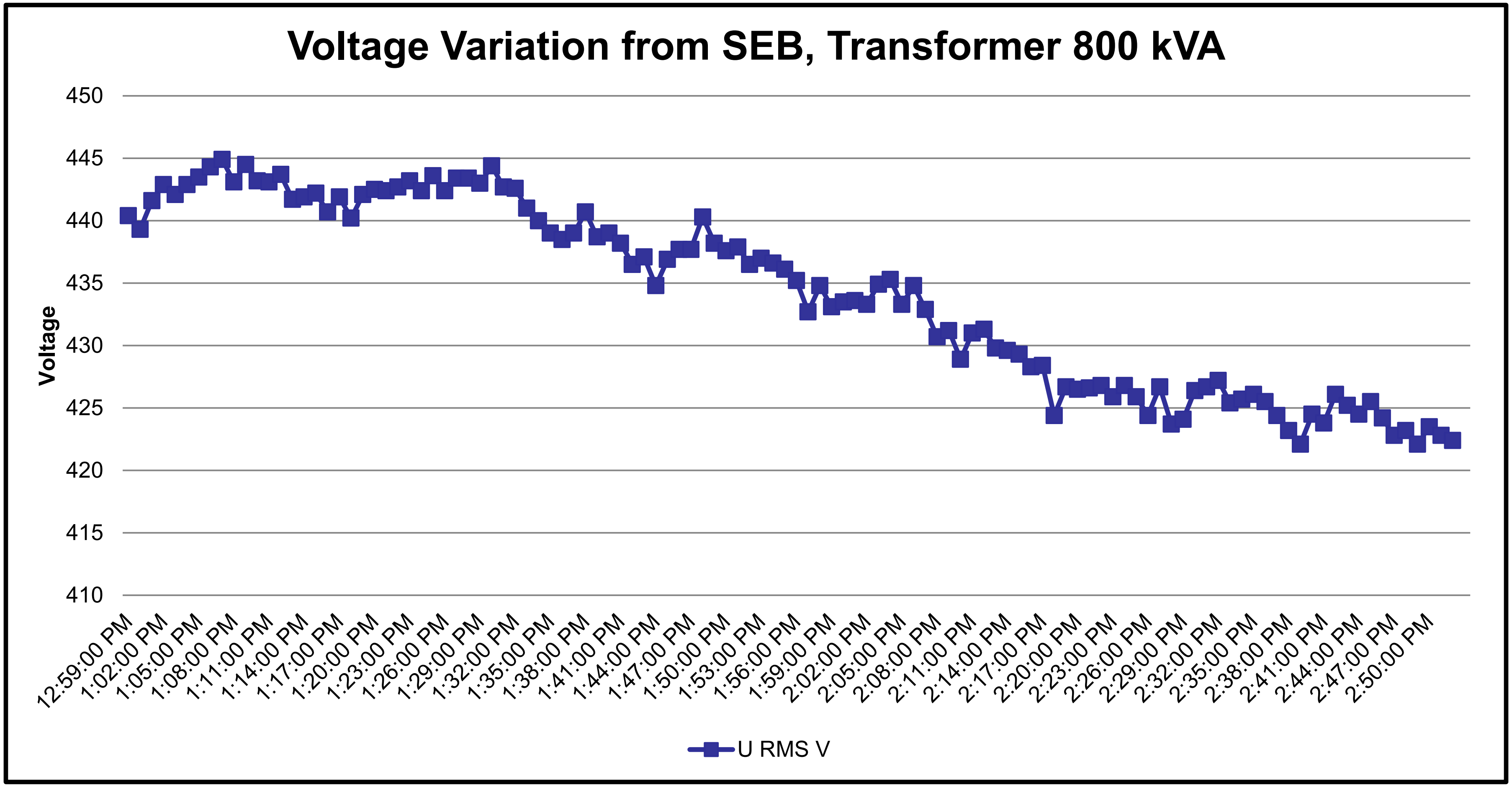
OPTIMIZE PLANT VOLTAGE AT 415 V



OPTIMIZE PLANT VOLTAGE AT 415 V

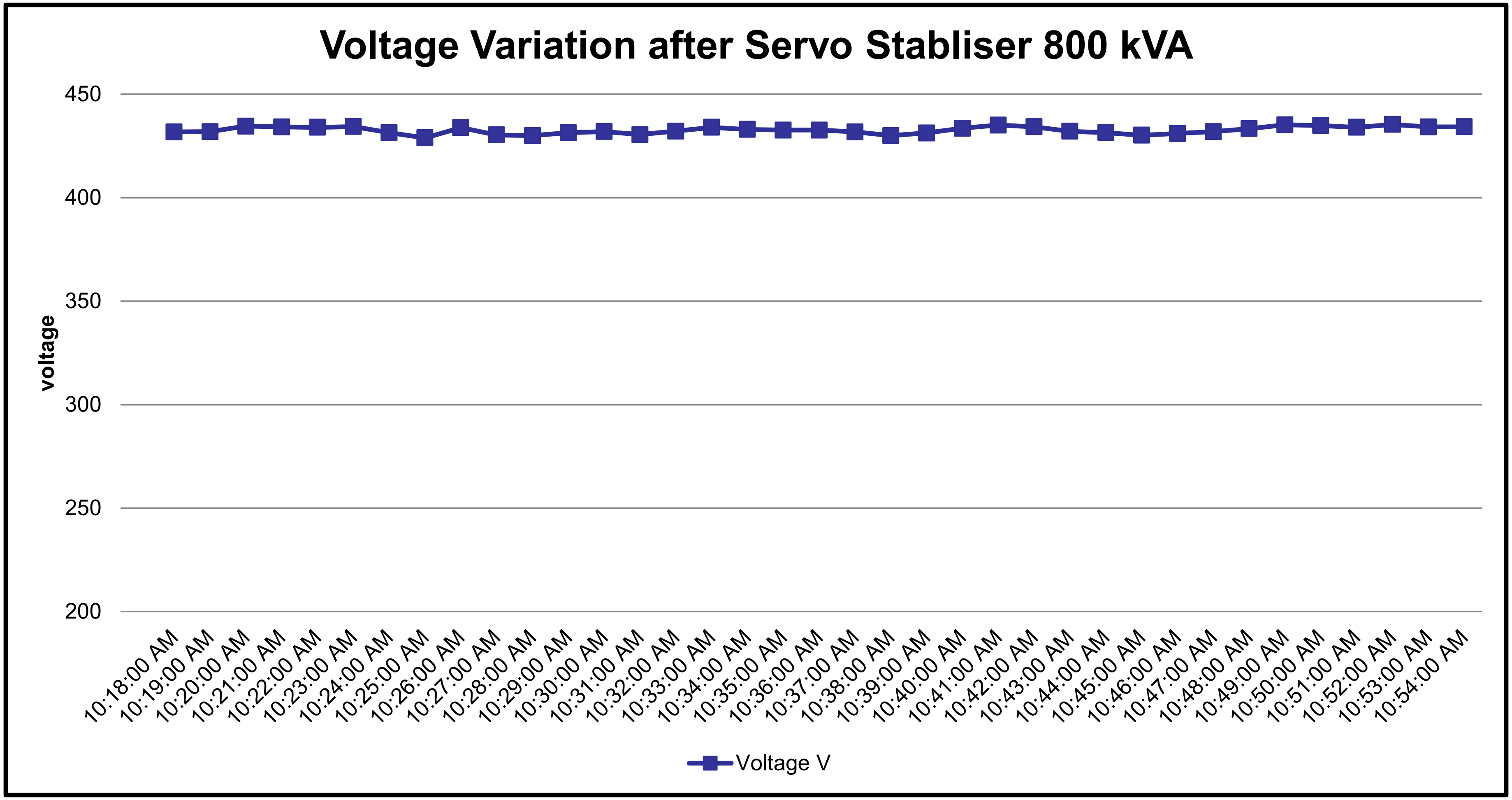


OPTIMIZE PLANT VOLTAGE AT 415 V



Voltage Variation from SEB, Transformer 800 kVA

OPTIMIZE PLANT VOLTAGE AT 415 V



OPTIMIZE PLANT VOLTAGE AT 415 V

- All motors are rated for 415 V, with a ± 10% tolerance
- Voltage fluctuations very high – threat to the operation / life of the plant equipments -
- Plant motors also loaded between 40 – 70 %
- Except Dust Collectors, Compressors

OPTIMIZE PLANT VOLTAGE AT 415 V

- 1250 kVA Servo Stabliser is not working, giving same output as input
- 800 kVA voltage setting at very high 430 volts
- Some Cable sizes and bus bars sizes are under sized
- Voltage drop 5-6 volts from transformer to panel

OPTIMIZE PLANT VOLTAGE AT 415 V

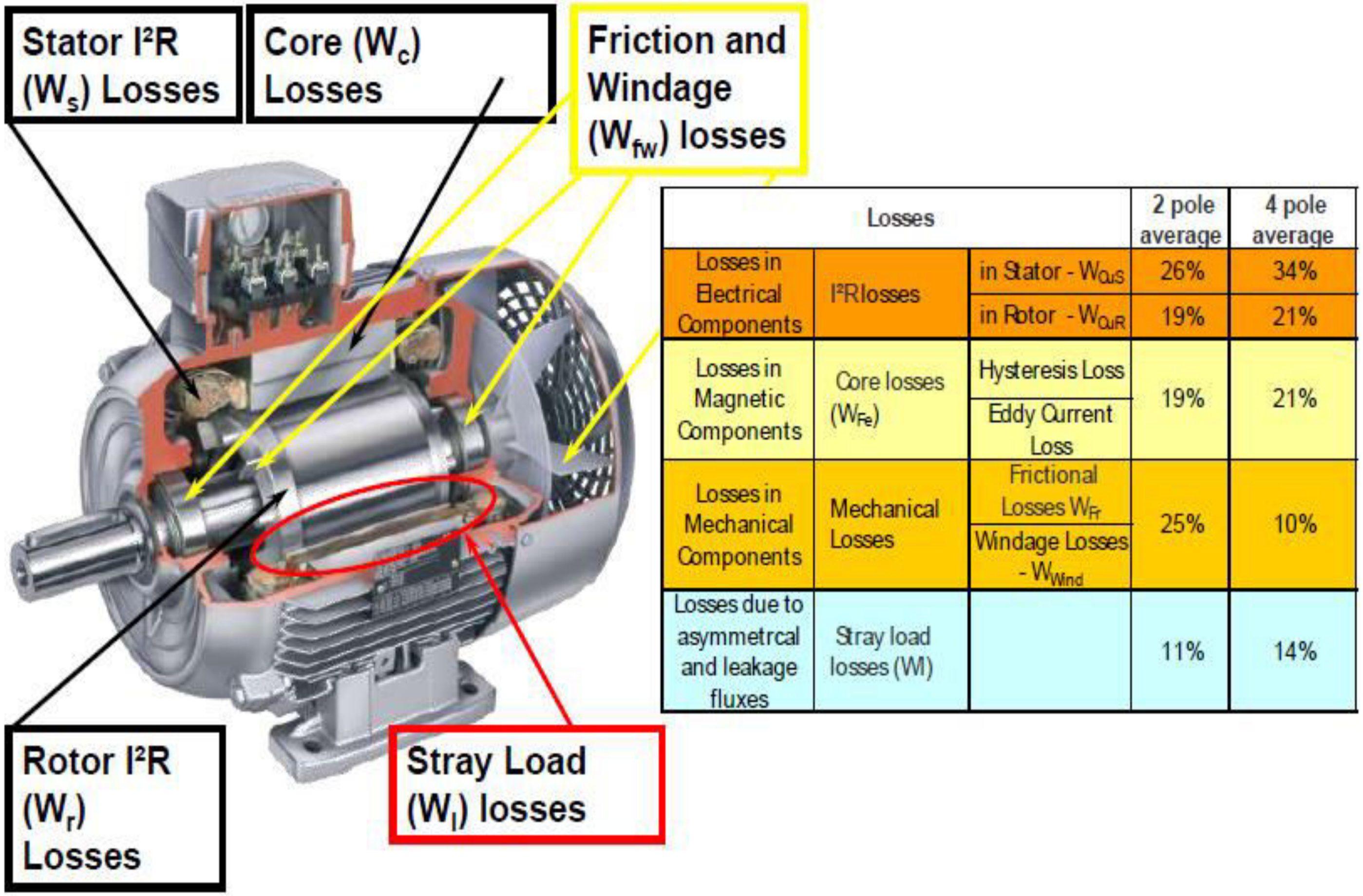
- Annual Bill – 4.5 crores
- Present Voltage level – 390 - 450 V
- Recommend to optimize the voltage to 410 V.
- Annual Savings : @ 1% : 4.5 lakhs

Already implemented during the audit in EOU section

OPTIMIZE PLANT VOLTAGE AT 415 V

Annual Saving	**- Rs 4.50 Lakhs**
Investment	**- Nil**

MOTOR LOSSES



Stator I^2R (W_s) Losses

Core (W_c) Losses

Friction and Windage (W_{fw}) losses

Rotor I^2R (W_r) Losses

Stray Load (W_l) losses

Losses			2 pole average	4 pole average
Losses in Electrical Components	I^2R losses	in Stator - W_{CuS}	26%	34%
		in Rotor - W_{CuR}	19%	21%
Losses in Magnetic Components	Core losses (W_{Fe})	Hysteresis Loss Eddy Current Loss	19%	21%
Losses in Mechanical Components	Mechanical Losses	Frictional Losses W_{Fr} Windage Losses - W_{Wind}	25%	10%
Losses due to asymmetrcal and leakage fluxes	Stray load losses (Wl)		11%	14%

WHY MOTORS ARE BECOMING LESS EFFICIENT

1

- **Over Sized / Under loaded Motors**

2

- **Improper Supply Voltage**

3

- **Use of Less Efficient Motors**

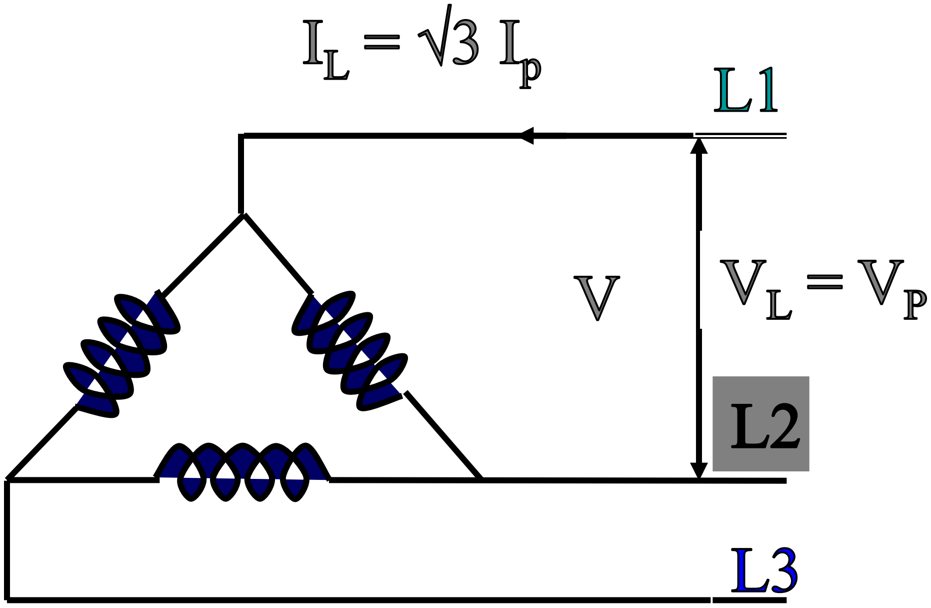
4

- **Poor Power Factor**

5

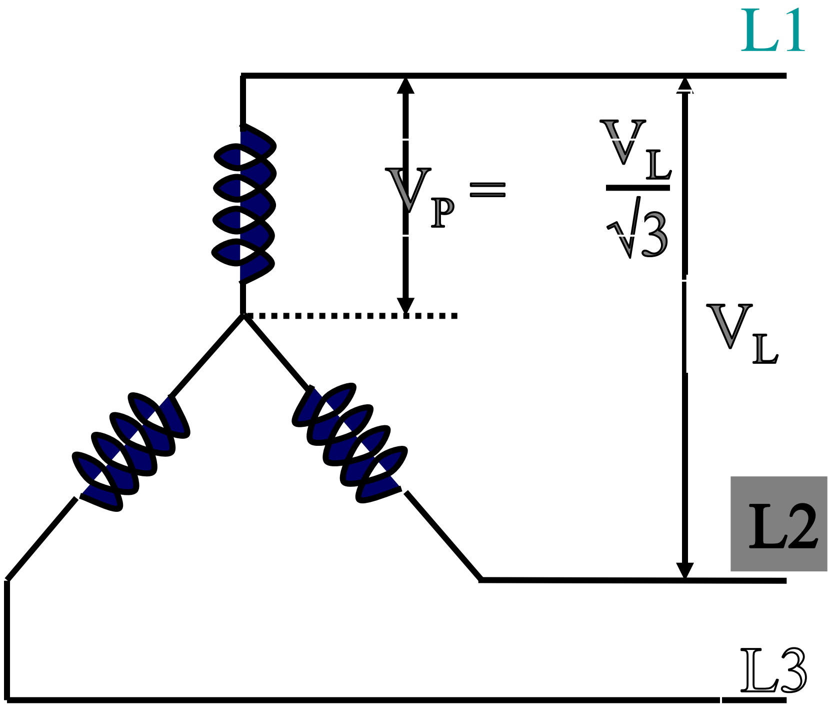
- **Rewinding of Motors**

STAR AND DELTA CONNECTION


$I_L = \sqrt{3}\ I_p$

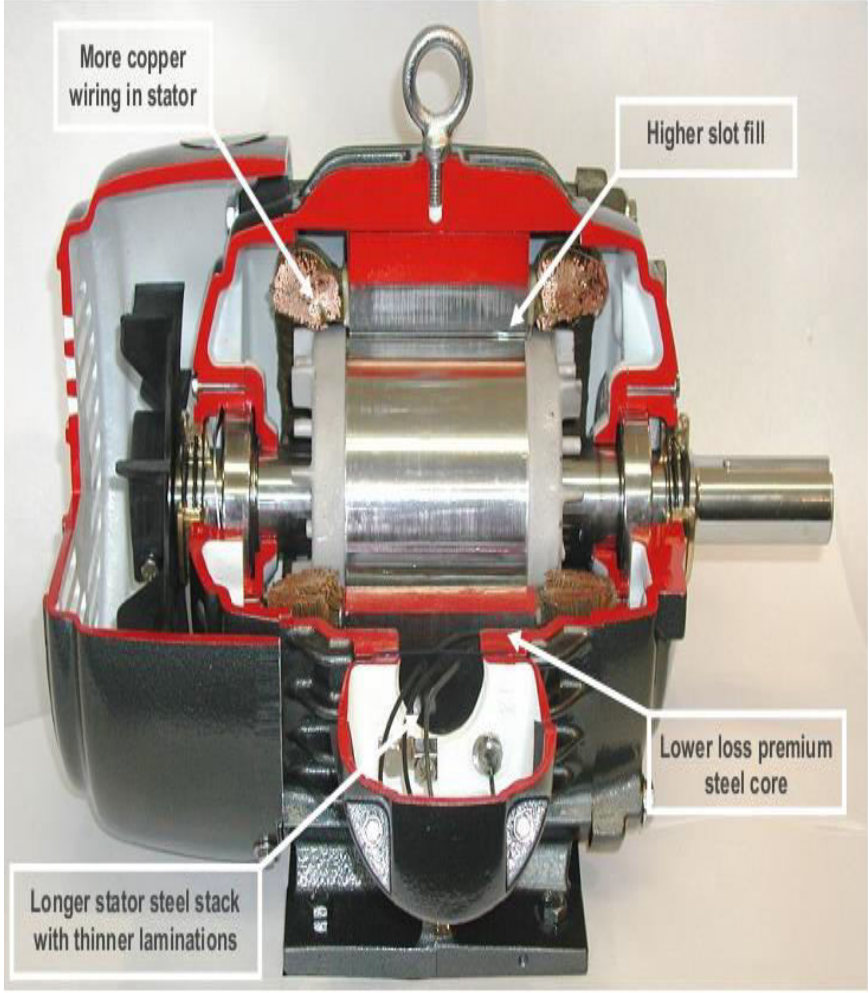
$V_L = V_P$

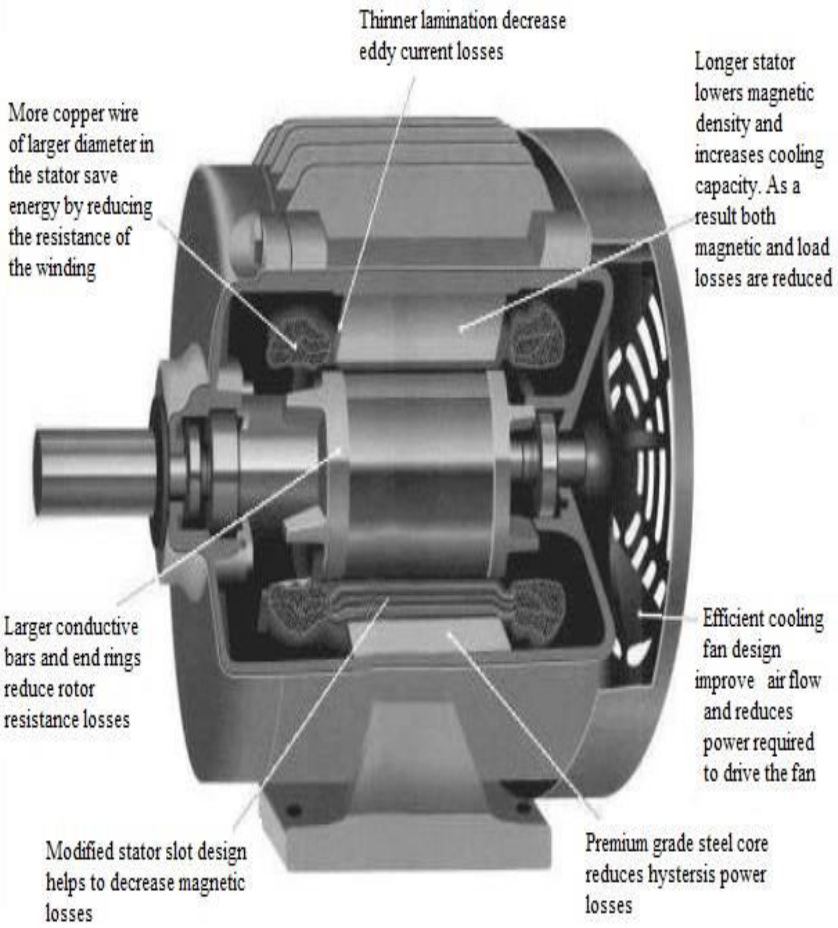
Delta connection


$V_P = \frac{V_L}{\sqrt{3}}$

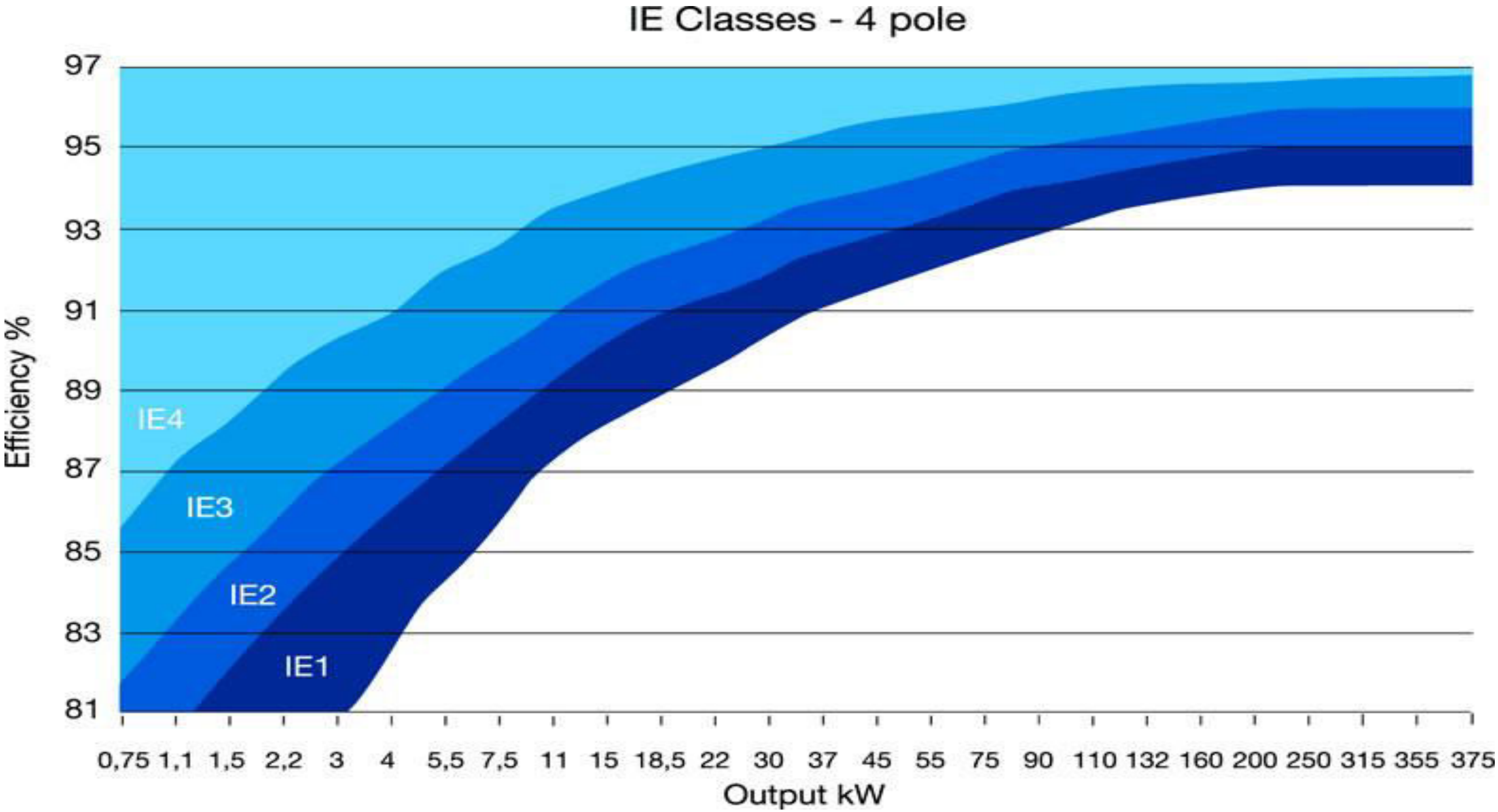
Star connection

MOTOR LOSSES





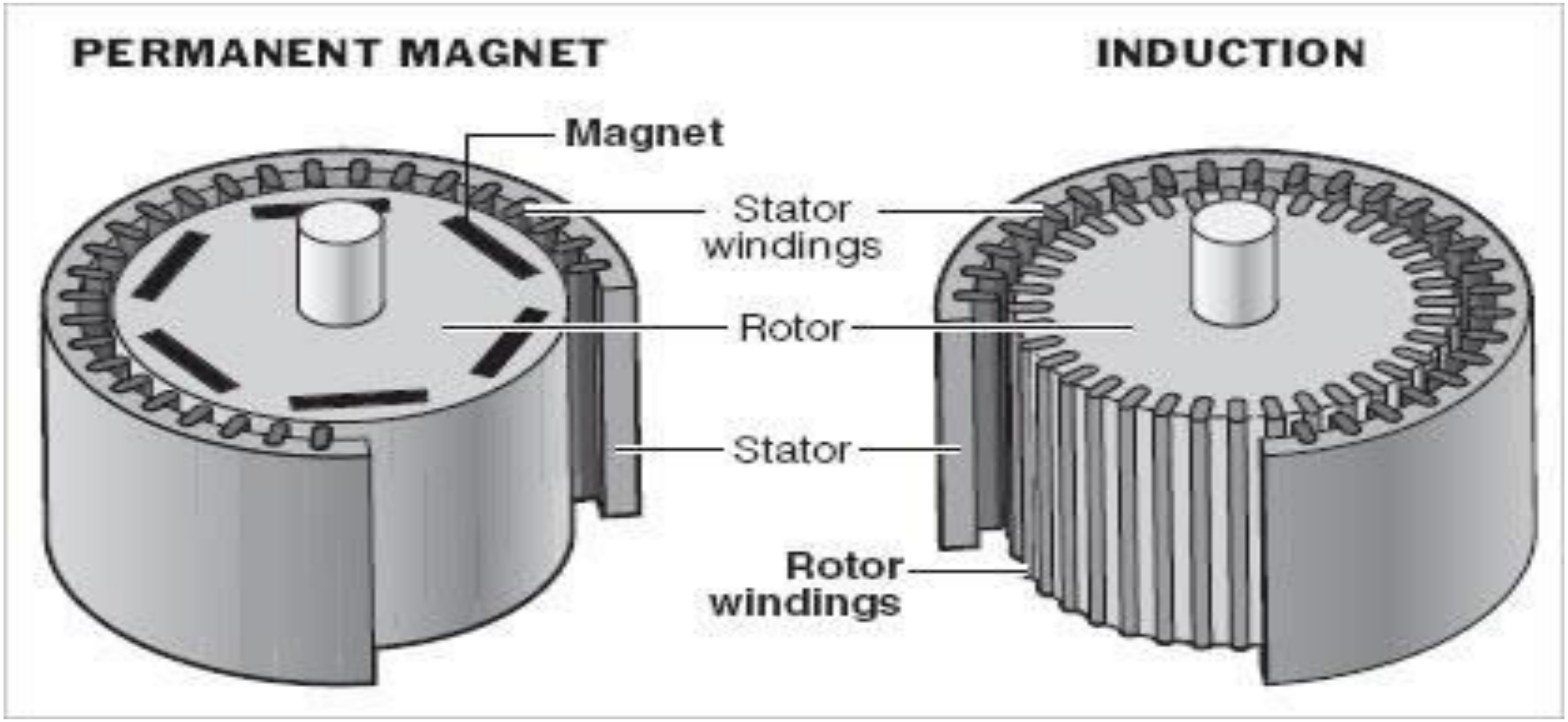
MOTOR EFFICIENCY CLASS



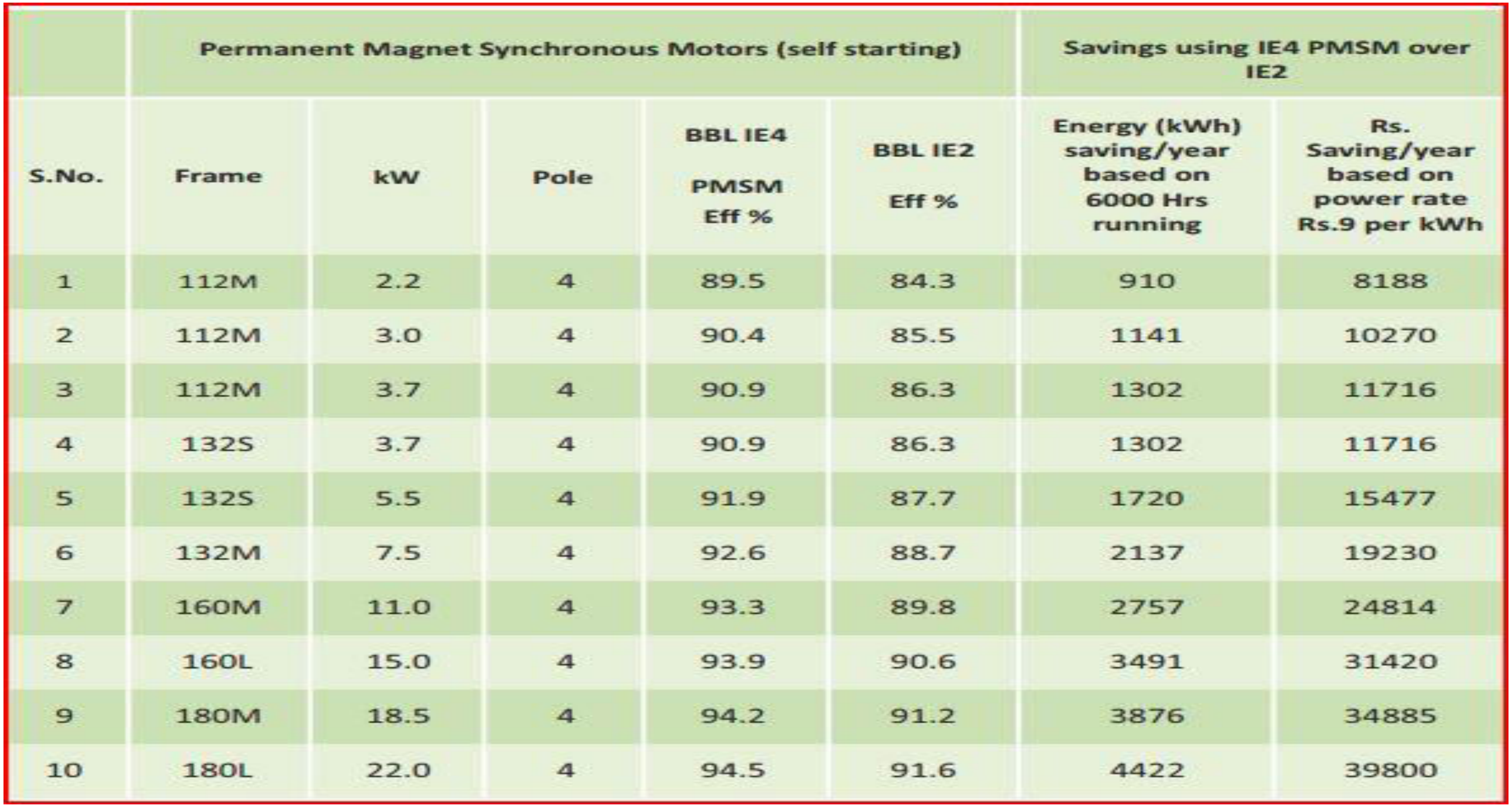
MOTOR REWINDING

- Bearing failure
  - Rotor scratches stator
  - Air gap becomes uneven
    - Net torque developed is low
    - Causes drop in efficiency
  - Maximum 5 times motor can undergo rewinding – normal failure

PERMANENT MAGNET SYNCHRONOUS MOTOR

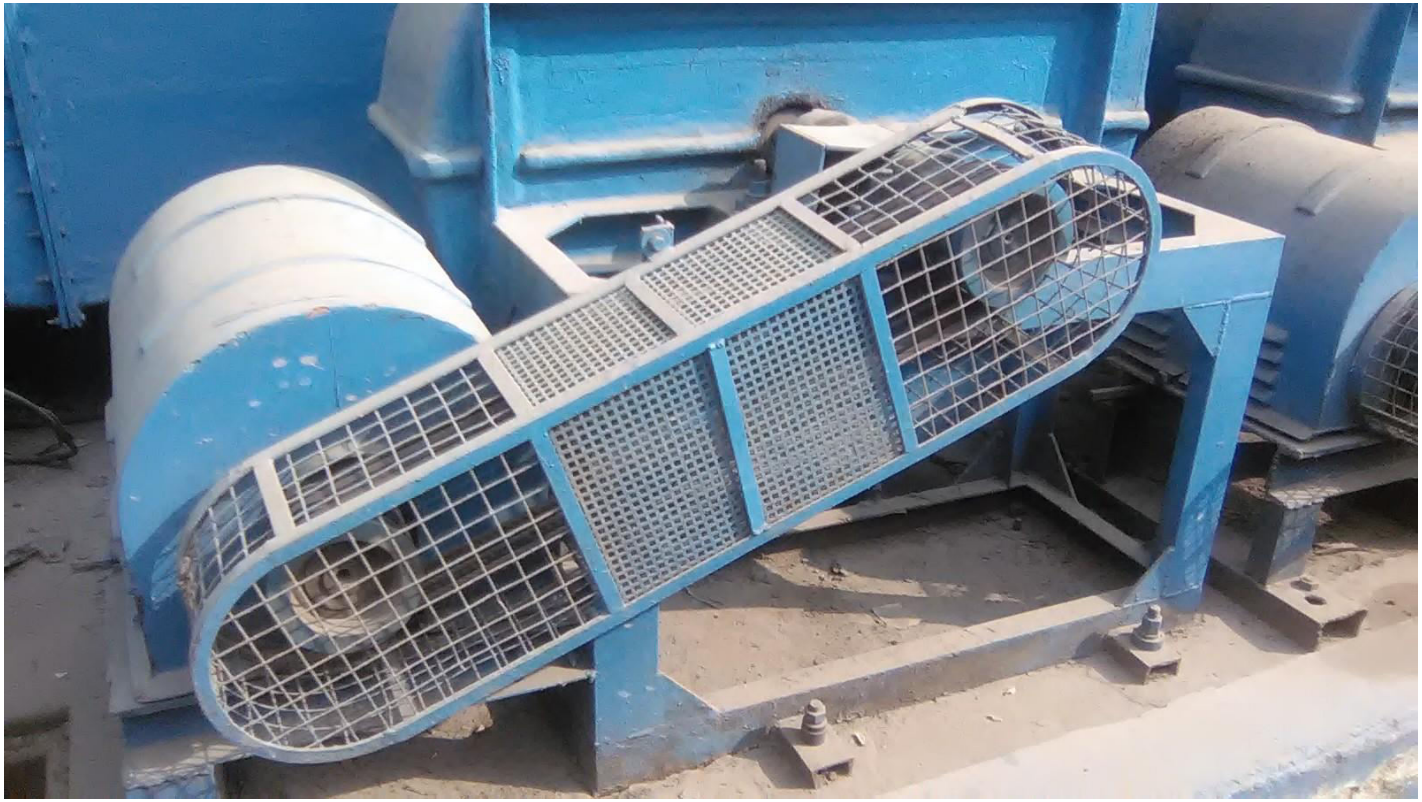


PERMANENT MAGNET SYNCHRONOUS MOTOR

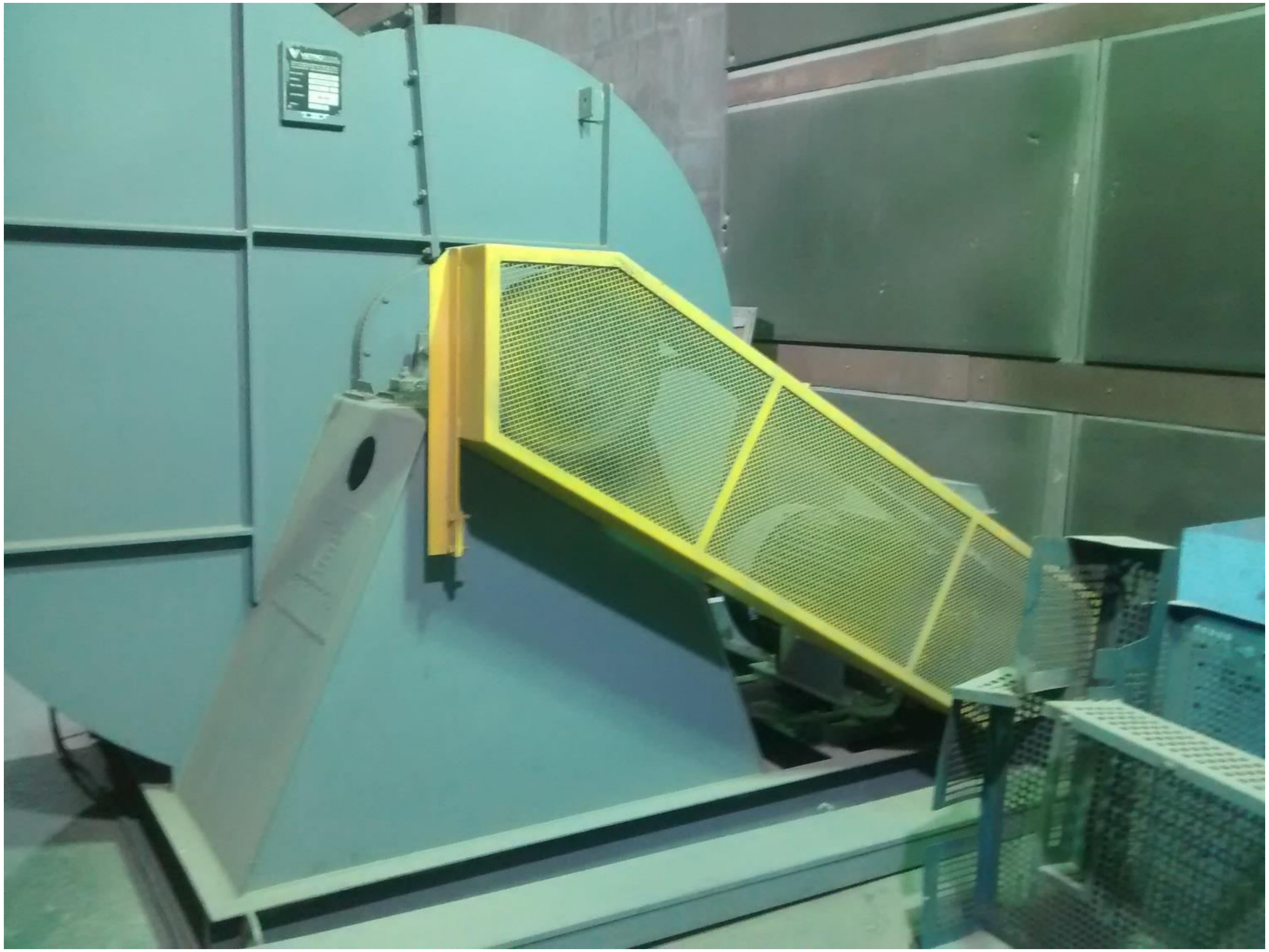


	Permanent Magnet Synchronous Motors (self starting)					Savings using IE4 PMSM over IE2	
S.No.	Frame	kW	Pole	BBL IE4 PMSM Eff %	BBL IE2 Eff %	Energy (kWh) saving/year based on 6000 Hrs running	Rs. Saving/year based on power rate Rs.9 per kWh
1	112M	2.2	4	89.5	84.3	910	8188
2	112M	3.0	4	90.4	85.5	1141	10270
3	112M	3.7	4	90.9	86.3	1302	11716
4	132S	3.7	4	90.9	86.3	1302	11716
5	132S	5.5	4	91.9	87.7	1720	15477
6	132M	7.5	4	92.6	88.7	2137	19230
7	160M	11.0	4	93.3	89.8	2757	24814
8	160L	15.0	4	93.9	90.6	3491	31420
9	180M	18.5	4	94.2	91.2	3876	34885
10	180L	22.0	4	94.5	91.6	4422	39800

Replace Belt driven Fume Extractor with Direct Driven System



Replace Belt driven Fume Extractor with Direct Driven System



Replace Belt driven Fume Extractor with Direct Driven System

Belt driven mechanism

- Inefficient method
- loss of 7-8% of total operational power
- Motor can be directly coupled to fan to avoid transmission losses

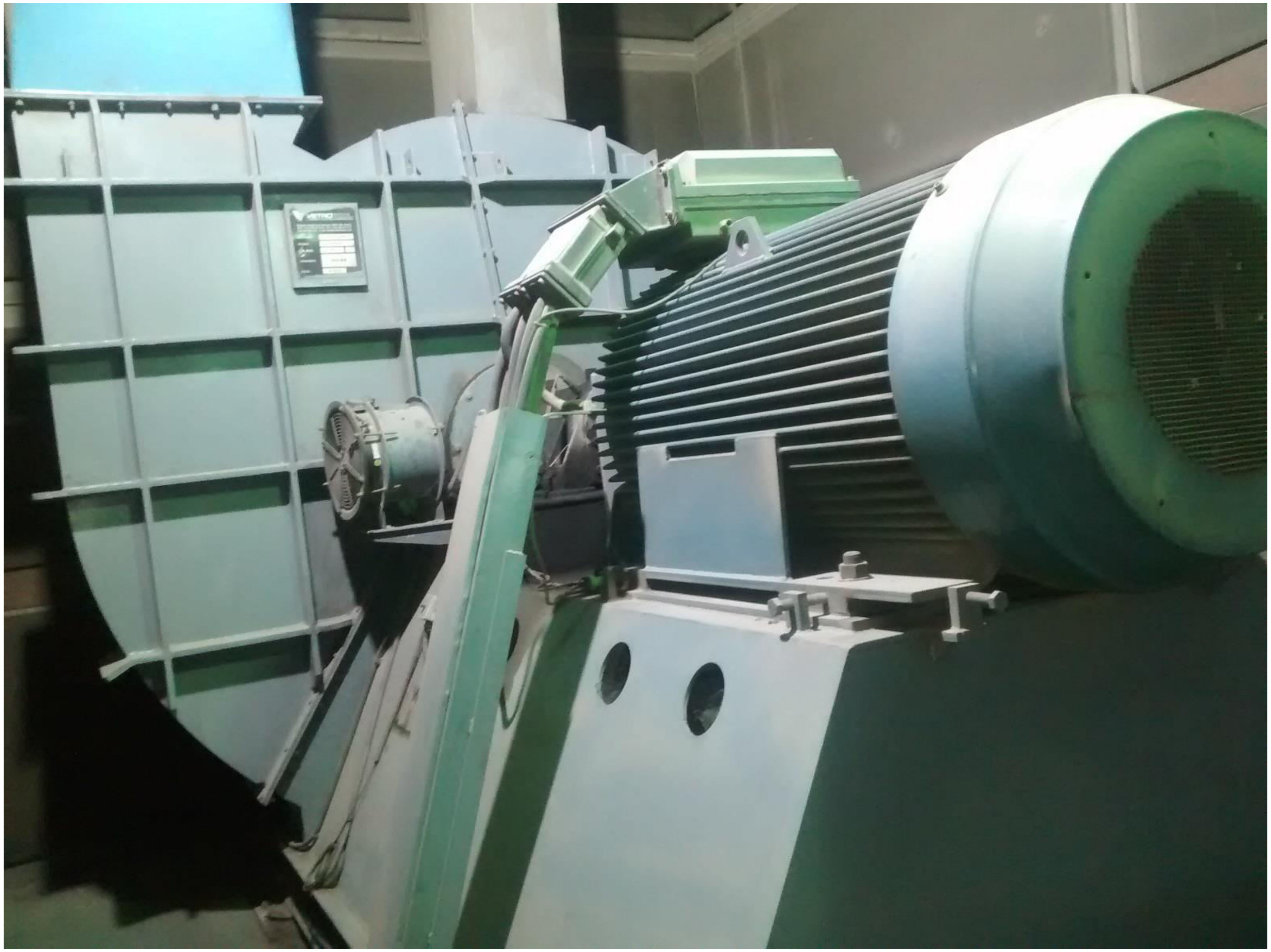
Action Plan

- Couple motor directly with blower
- Save the transmission losses

Replace Belt driven Fume Extractor with Direct Driven System

Direct Driven System

Replace Belt driven Fume Extractor with Direct Driven System



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Replace Belt driven Fume Extractor with Direct Driven System

	Name	Measured kW
CPPR Chrome	Fume Extractor Blower Parkerising	3
	ACP-2 Fume Extractor	9.7
	ACP-3 Fume Extractor	8.9
	ACP-4 Fume Extractor	13.09
	ACP-1 Fume Extractor	3.9
	ID Plant Blower	9.2
	Flue Extractor-EV Plating	6.68
C2D1	Fume Extractor C2D1-1	3.6
	Fume Extractor C2D1 -2	2.9
Total		60.97 kW

Replace Belt driven Fume Extractor with Direct Driven System

Saving = 5 % x 60.97 kW x 24 hrs/day x 305 Days x 8.14 Rs/kWh

Annual Saving - Rs 1.87 Lakhs
Investment - Rs 1.00 Lakhs
Simple Payback - 7 Months

Cables

Types of Cables

Types

- High Voltage (Voltage > 1.1 kV)
- Low Voltage (Voltage < 1.1 kV)
    - ✓ Control
    - ✓ Instrumentation (Shielded)
    - ✓ Data Cable (Profibus /Lan /Modbus /Fiber/Optics)

Losses in Cables

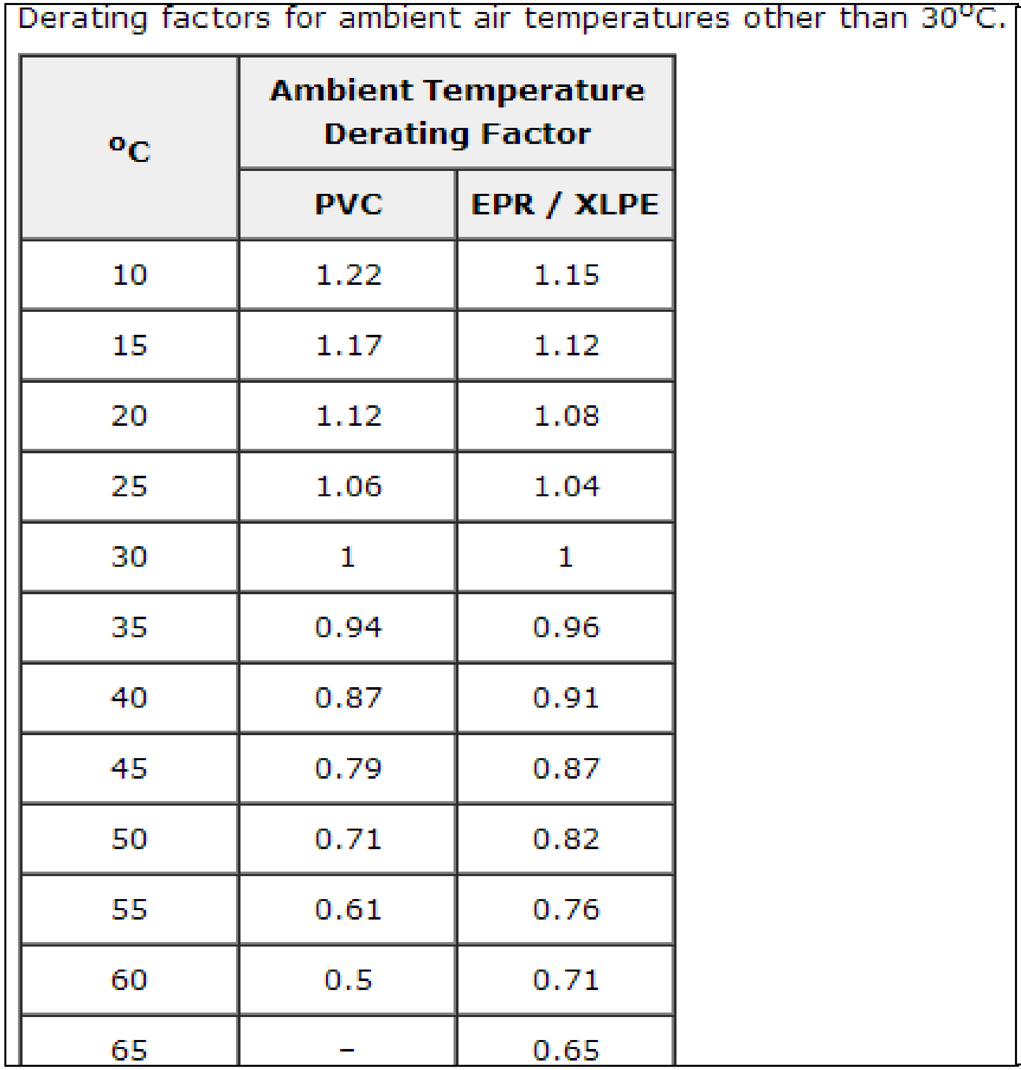
Un-avoidable Losses

- Copper Losses I^2R (Load losses)
- Voltage Drop
- Induction Losses
- Capacitance Losses

Avoidable Losses

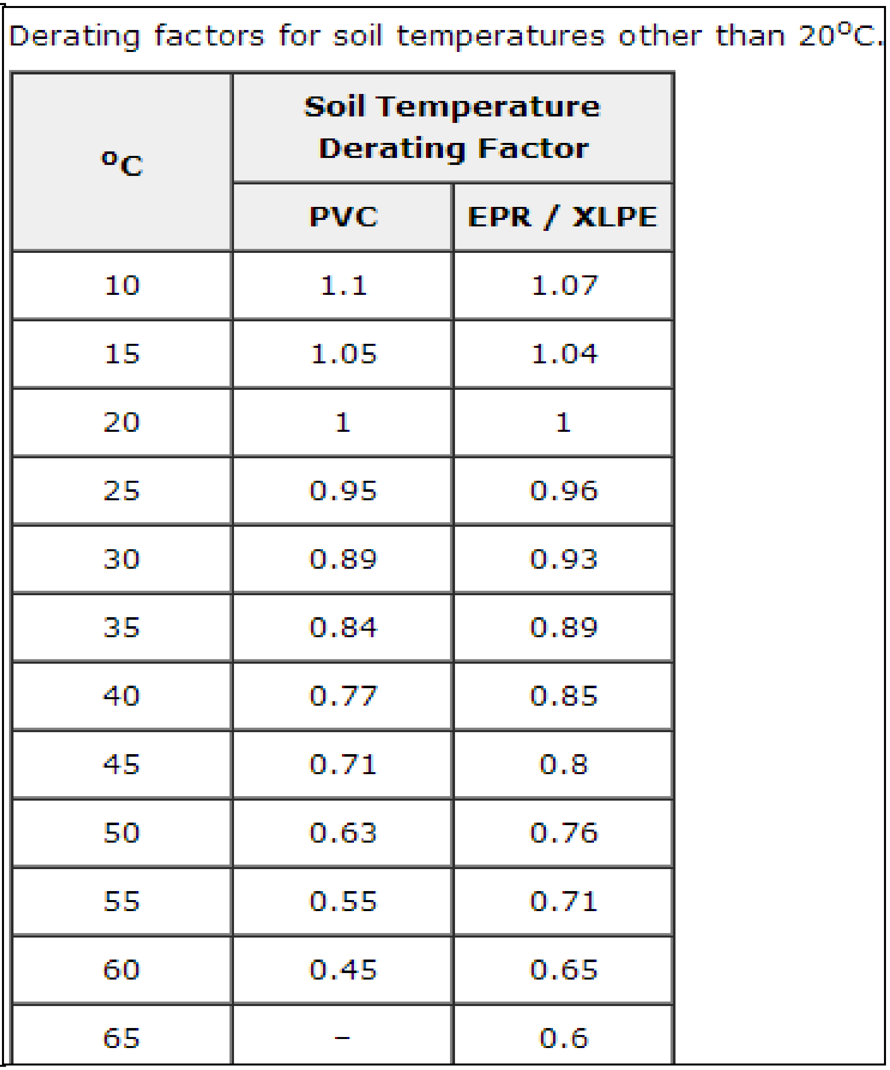
- Jointing Losses (Heating/Thimble Burning)
- Bus Bar Connection
- Thimble losses
- Material change (Copper to Aluminum)

De rating factors



Derating factors for ambient air temperatures other than 30°C.

°C	Ambient Temperature Derating Factor	
	PVC	EPR / XLPE
10	1.22	1.15
15	1.17	1.12
20	1.12	1.08
25	1.06	1.04
30	1	1
35	0.94	0.96
40	0.87	0.91
45	0.79	0.87
50	0.71	0.82
55	0.61	0.76
60	0.5	0.71
65	-	0.65



Derating factors for soil temperatures other than 20°C.

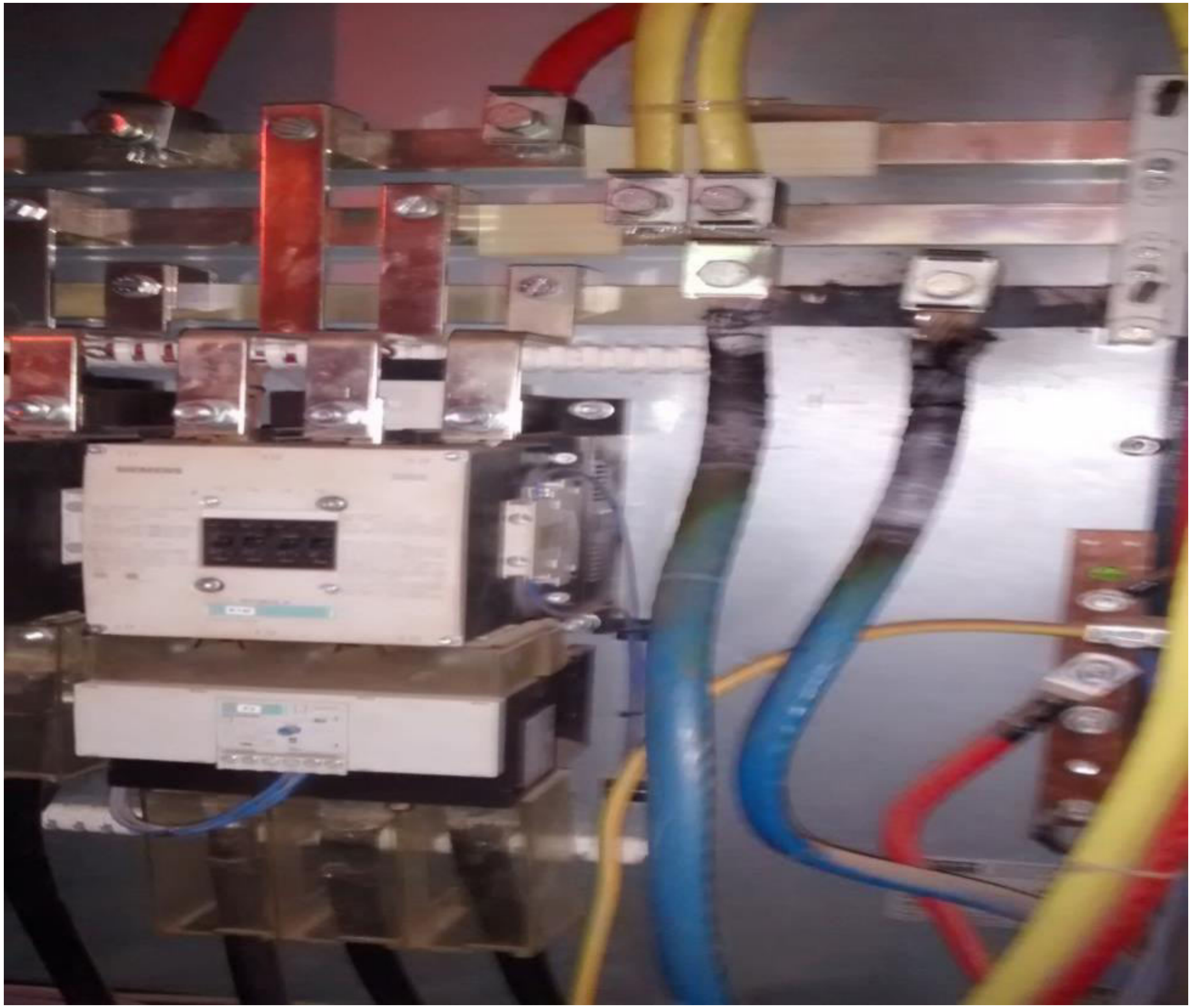
°C	Soil Temperature Derating Factor	
	PVC	EPR / XLPE
10	1.1	1.07
15	1.05	1.04
20	1	1
25	0.95	0.96
30	0.89	0.93
35	0.84	0.89
40	0.77	0.85
45	0.71	0.8
50	0.63	0.76
55	0.55	0.71
60	0.45	0.65
65	-	0.6

Losses in Cables due to over heating

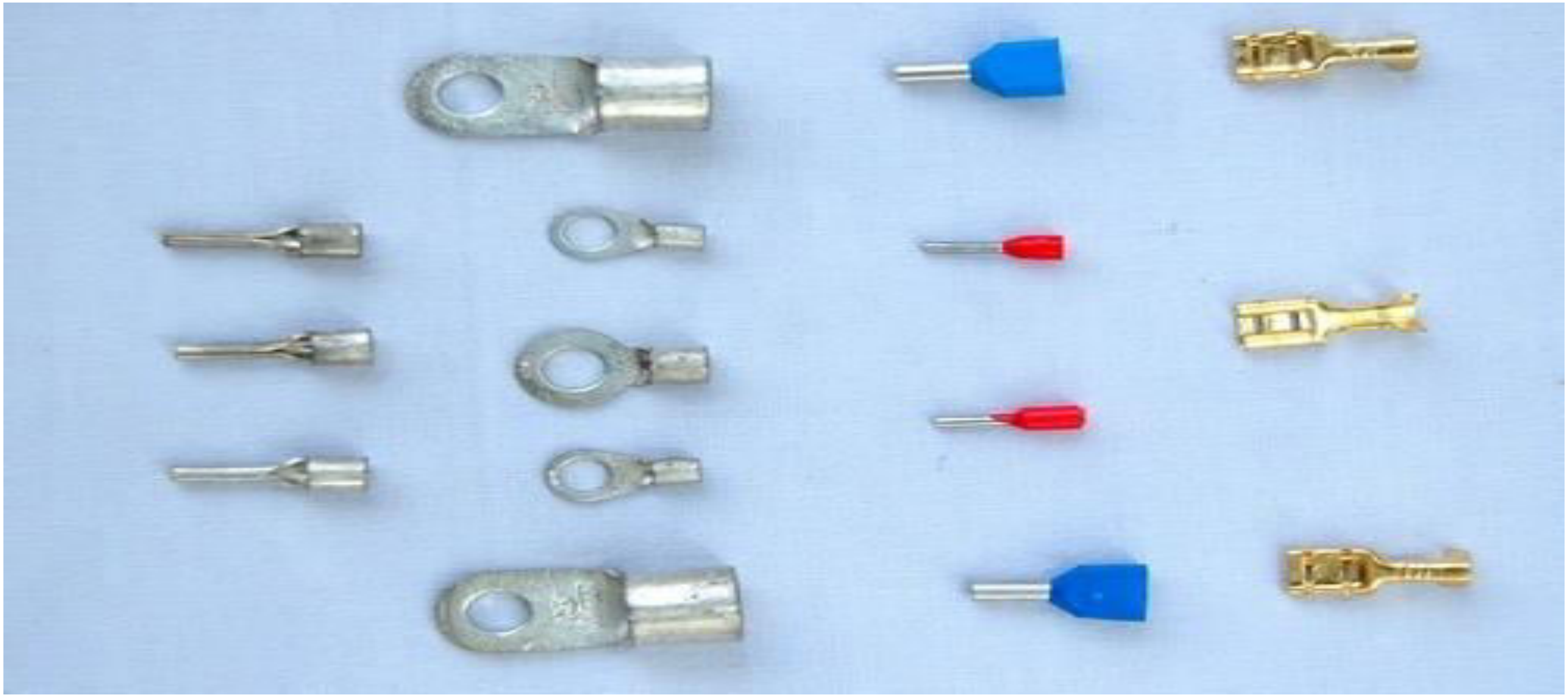

Ken Brinkman

- **Proper tightening of cable is very significant**

Losses in Cables due to over heating



Losses due to Wrong Cable Termination



- Use Right type of thimble at Right place

Losses in Cables

Case Study - 1

- **Cable Type - 3.5 Core 185 mm2 Al.**
- **Resistance - 0.164 ohm/kM**
- **Current Capacity - 280 Amperes**
- **Losses I2R - 280 x 280 x 0.164/1000 kW/kM**
- **Losses / kM - 12.86 kW**
- **Cost / Meter - Rs. 470/-**

Losses in Cables

Case Study - 1

- **Cable Type** - 3.5 Core 240 mm2 Al.
- **Resistance** - 0.125 ohm/kM
- **Current Capacity** - 330 Amperes
- **Losses I2R** - 330 x 330 x 0.125/1000 kW/kM
- **Losses / kM** - 13.61 kW
- **Cost / Meter** - Rs. 600/-

Losses in Cables

Case Study - 1

- **Cable Type** - 3.5 Core 240 mm2 Al.
- **Resistance** - 0.125 ohm/kM
- **Current Capacity** - 330 Amperes
- **Actual Load** - 280 Amperes
- **Losses I2R** - 280 x 280 x 0.125/1000 kW/kM
- **Losses / kM** - 9.8 kW

Losses in Cables

Case Study - 1

- **Difference - 3.8 kW**
- **Running hours - 8000 /Annum**
- **Cost - Rs. 8/Unit**
- **Saving - 2.43 Lakhs/Annum**
- **Additional Investment - 1.3 Lakhs**

Losses in Cables

- **Selection of Cable is very important**
- **Right selection can cost you more in project stage but cheaper in longer run**
- **Periodic health check is very important**
- **Thermal Imaging , loading on cables etc. needs to be checked regularly**

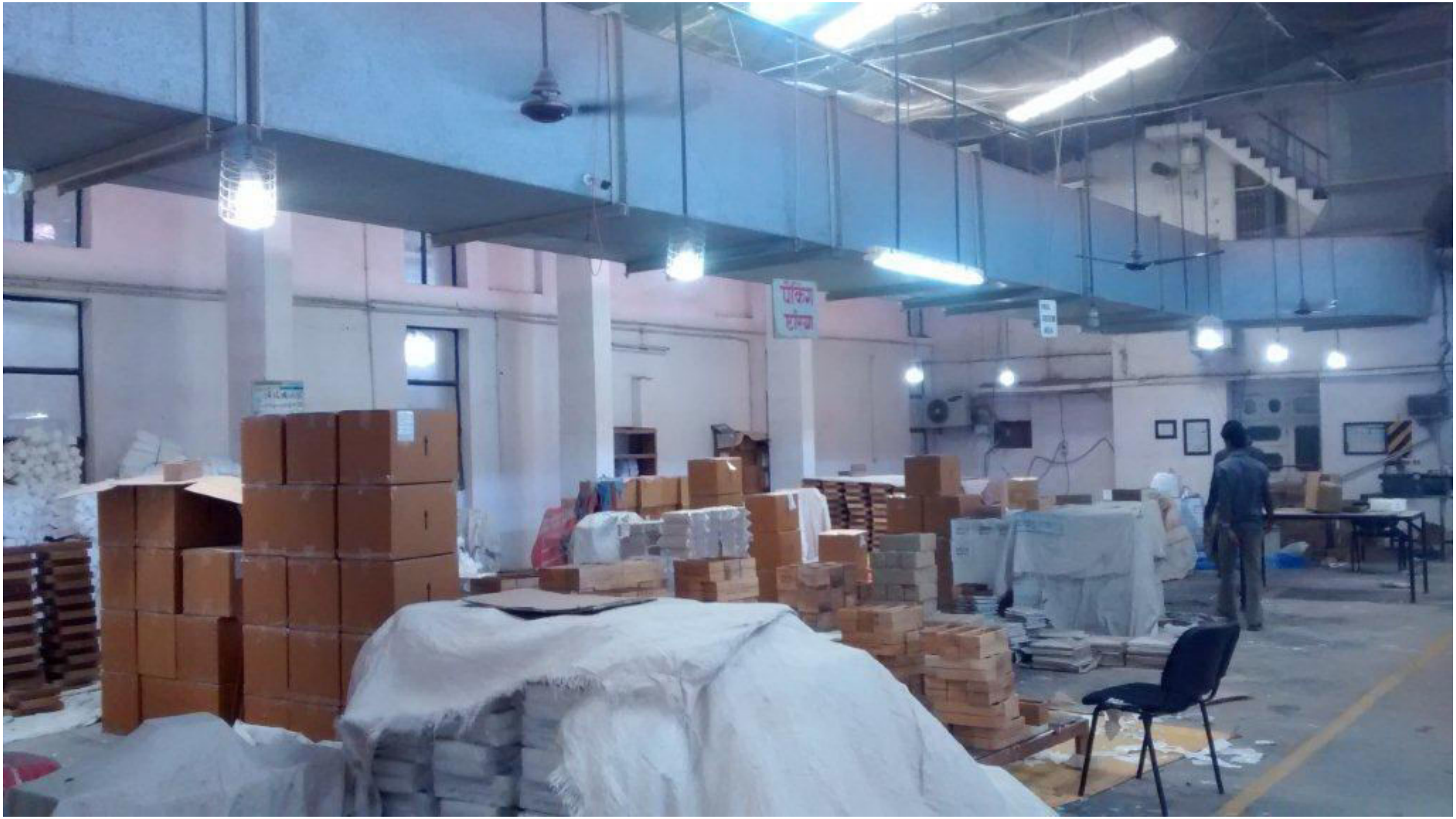
Stop idle operation of equipment's during lunch/Dinner and tea breaks

Presently

- Idle operation of equipment's during lunch hours
- Fans, tube lights, CFL, exhaust fans, conveyor and some machines were operational
- Idle operation is pure wastage of energy

Stop idle operation of equipment's during lunch/Dinner and tea breaks

Stop idle operation of equipment's during lunch/Dinner and tea breaks



Stop idle operation of equipment's during lunch/Dinner and tea breaks

Electrical Panels

Electrical Panels

Major Components of Electrical Panels

- Air Circuit Breakers (ACB)
- Moulded Case Circuit Breaker (MCCB)
- Switch Fuse Unit (SFU)
- Miniature Circuit Breaker (MCB)
- Bus Bars, Wiring & accessories

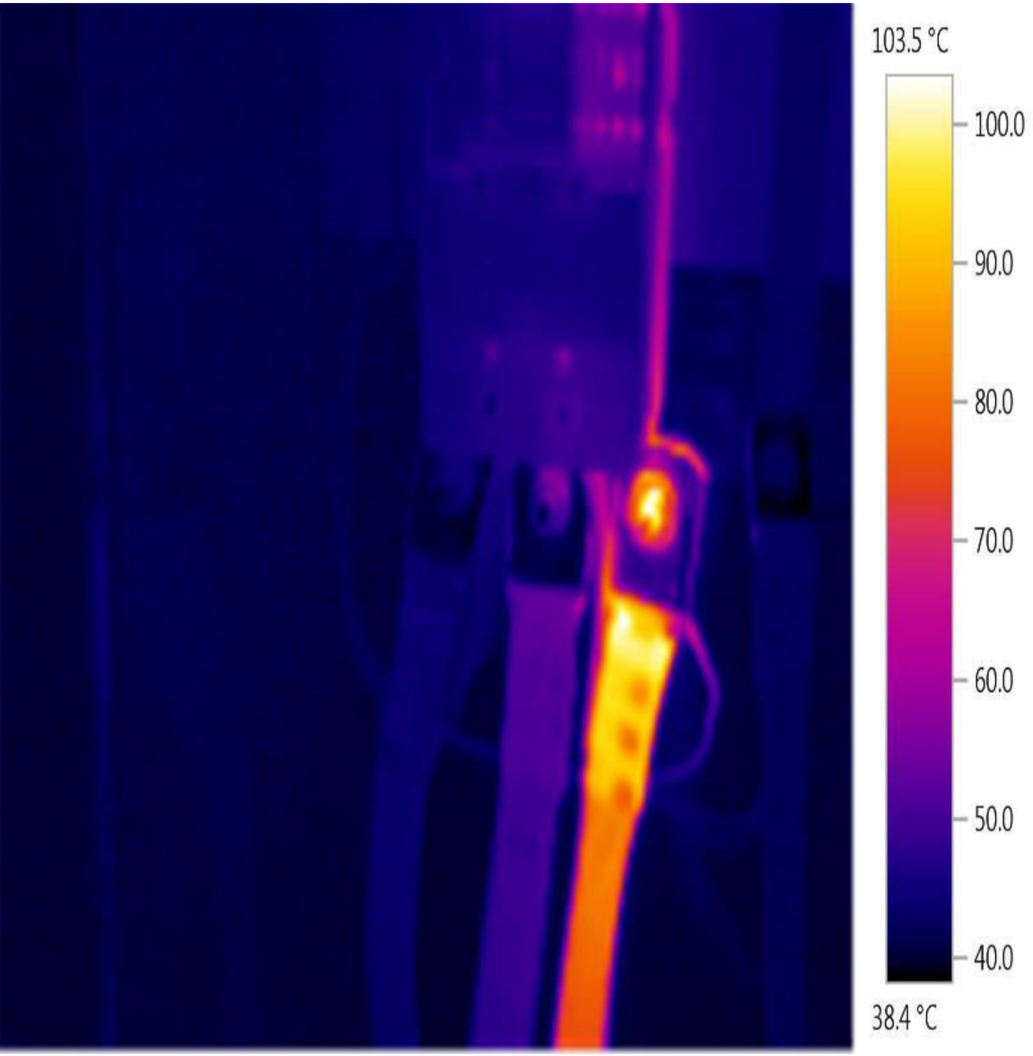
Electrical Panels

LOSSES IN THE PANELS

- Losses in Switch gears
- Losses in Wiring
- Losses in Bus Bars
- Losses in Indicators
- Losses in meters, Instrument Transformers
- Losses in Capacitors

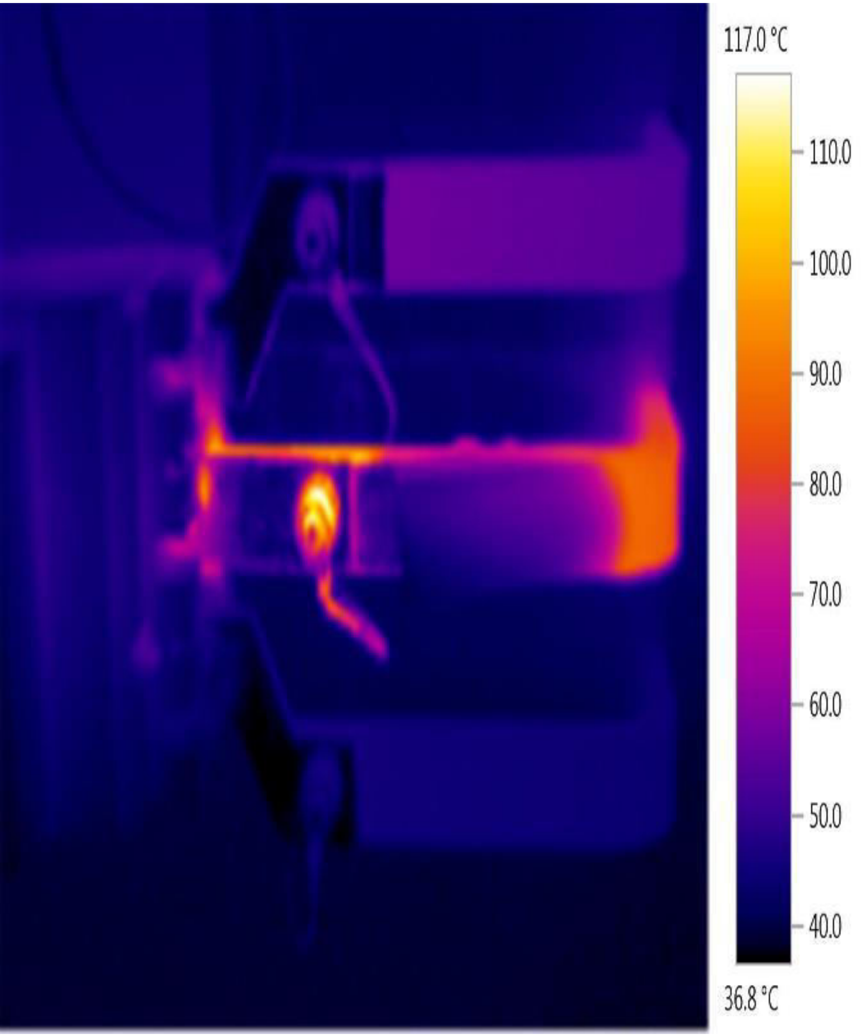
Electrical System

Main MCCB incomer

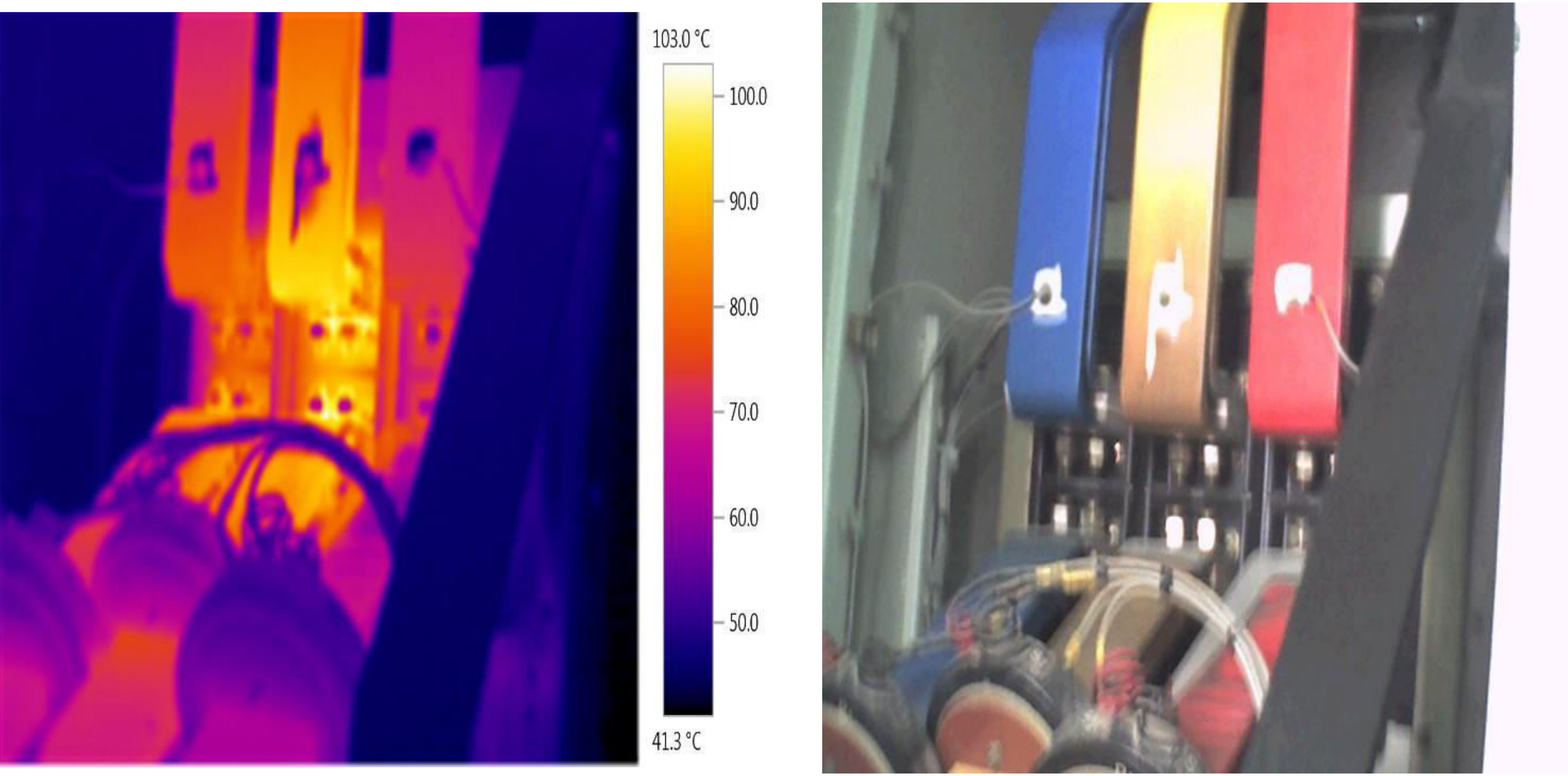


Electrical System

L.T ROOM RO Plant Main MCCB

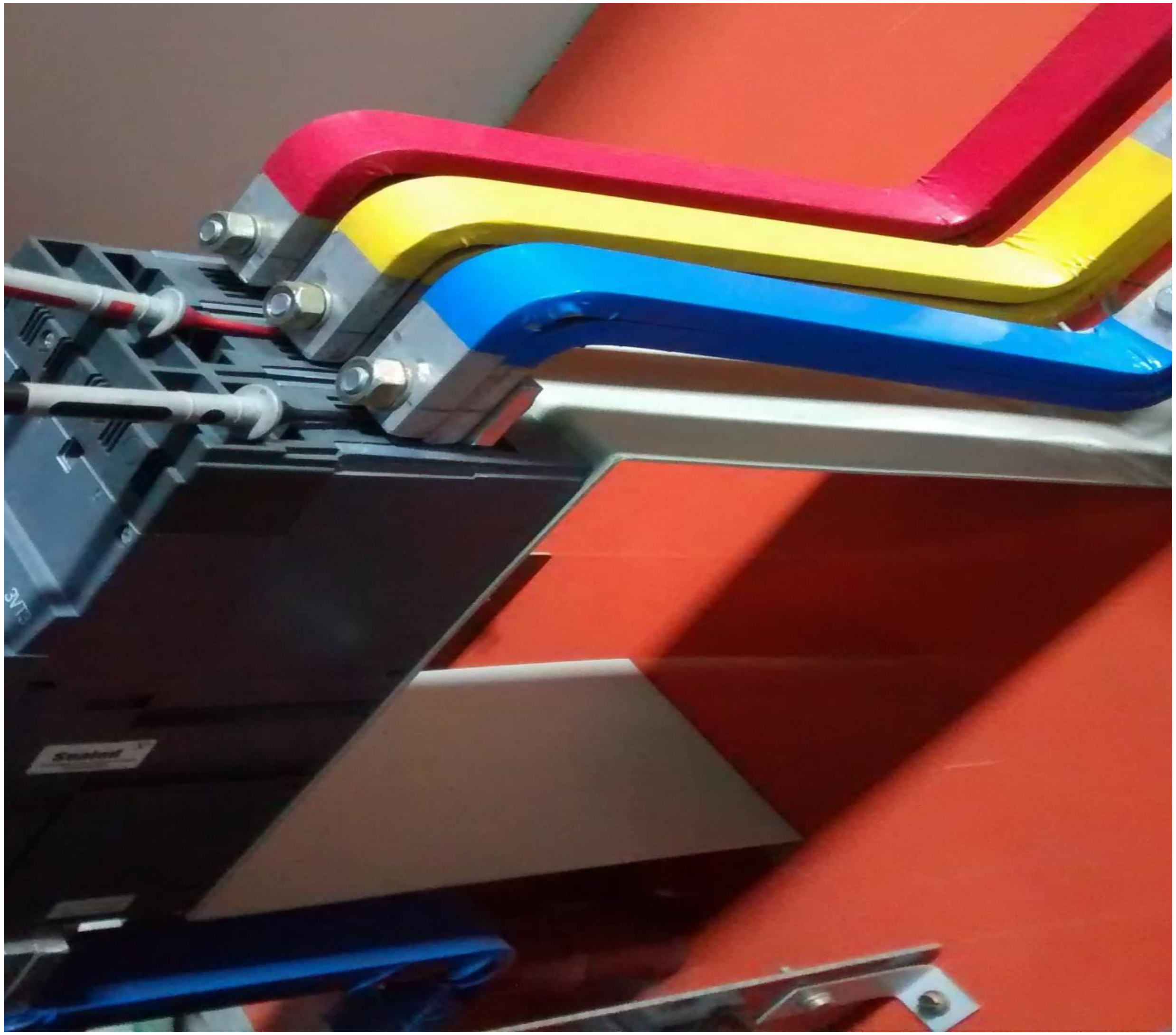


Thermal Imaging

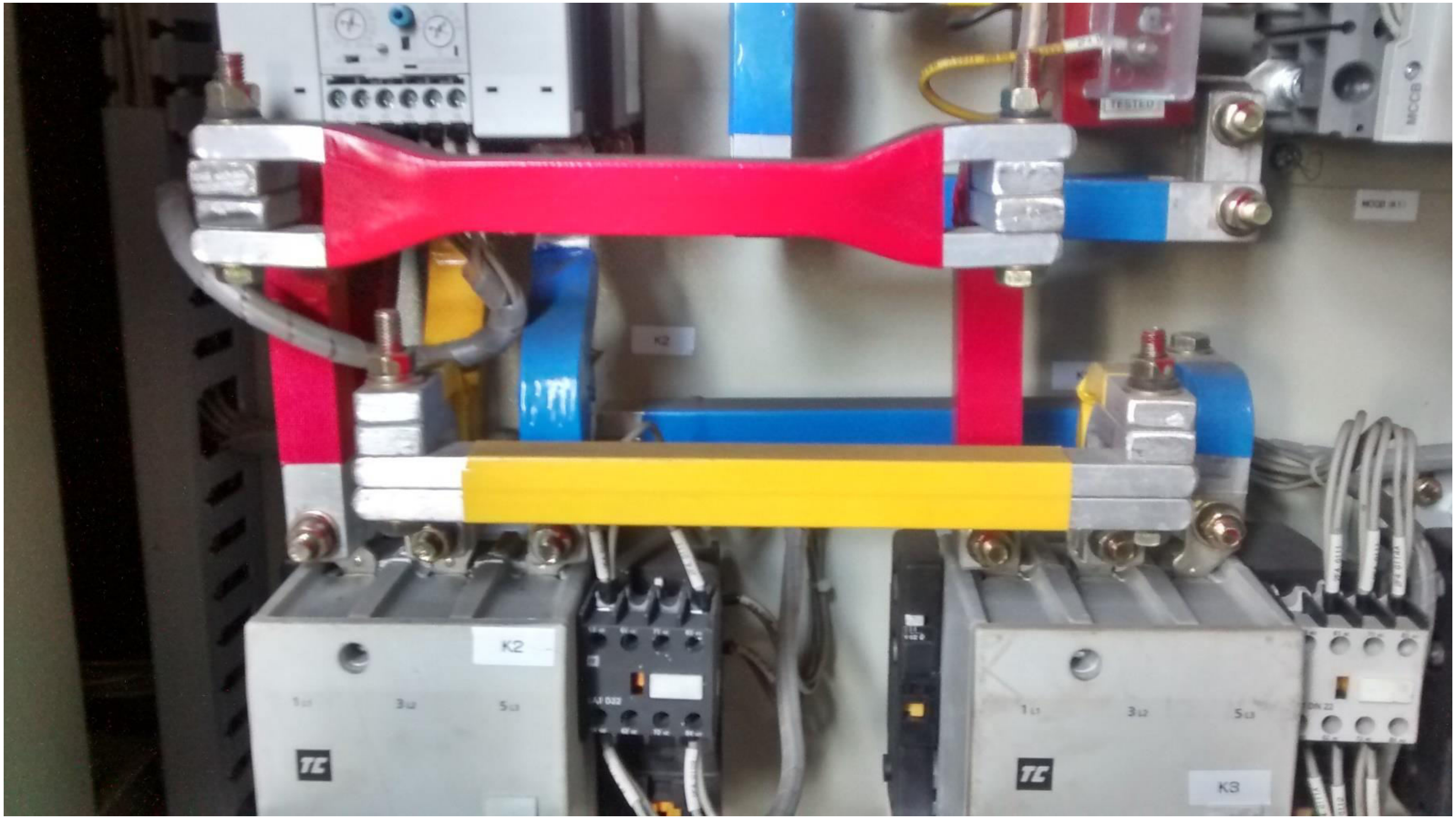


Air Circuit Breaker

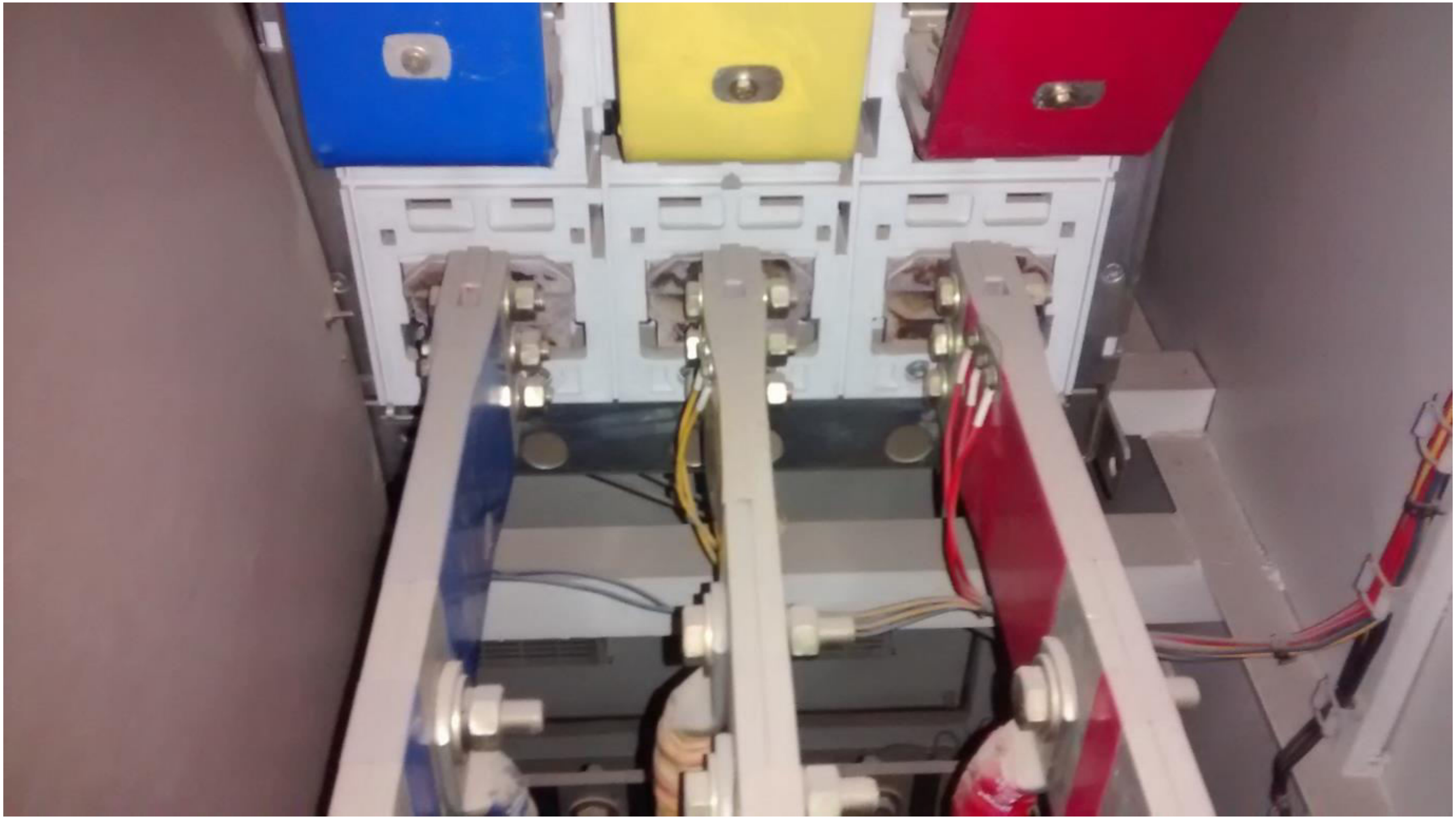
Losses due to overheating in Bus Bars



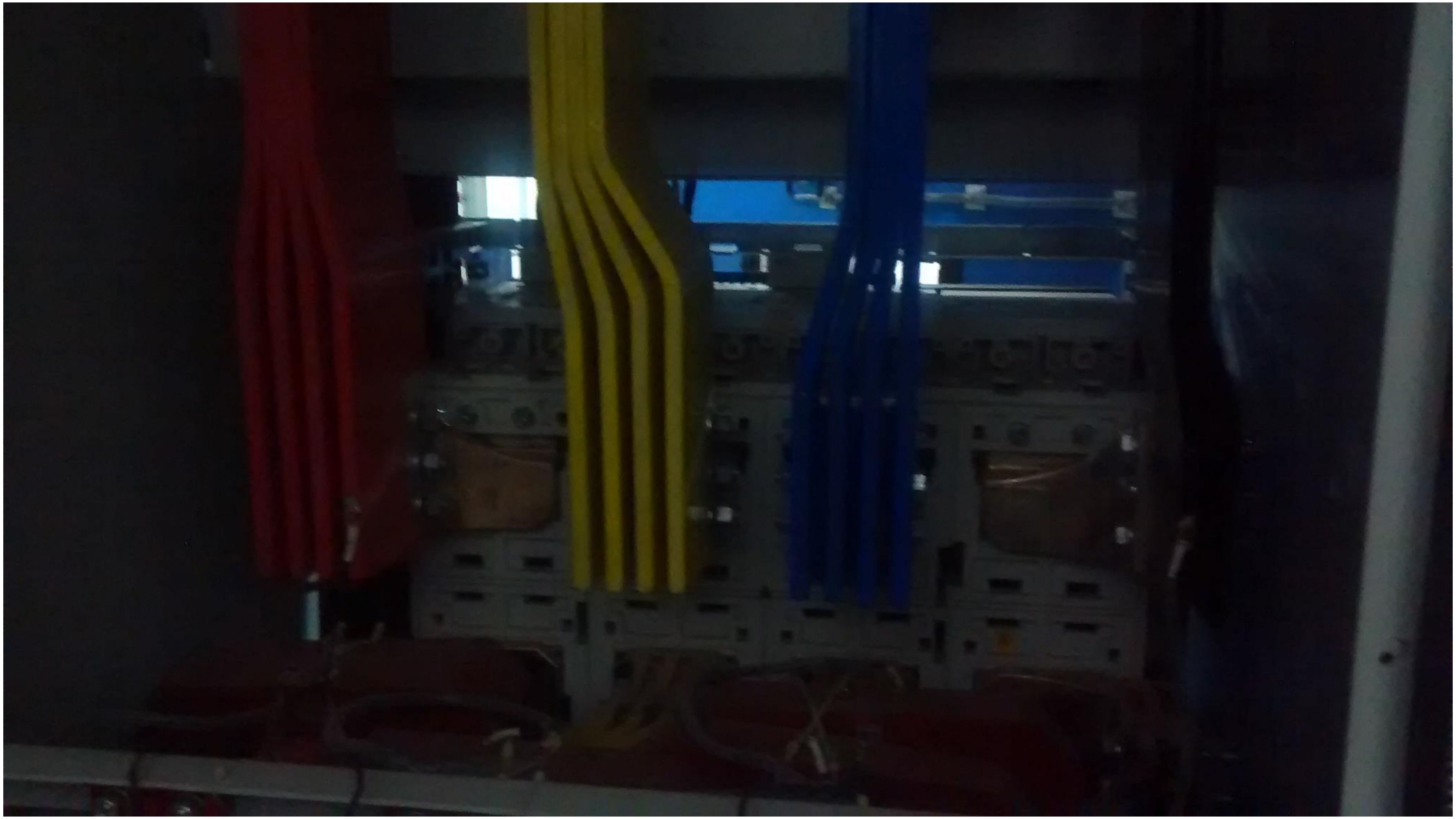
Losses due to overheating in Bus Bars



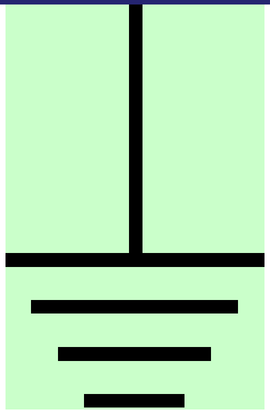
Losses due to overheating in Bus Bars



Losses due to overheating in Bus Bars



EARTHING / GROUNDING

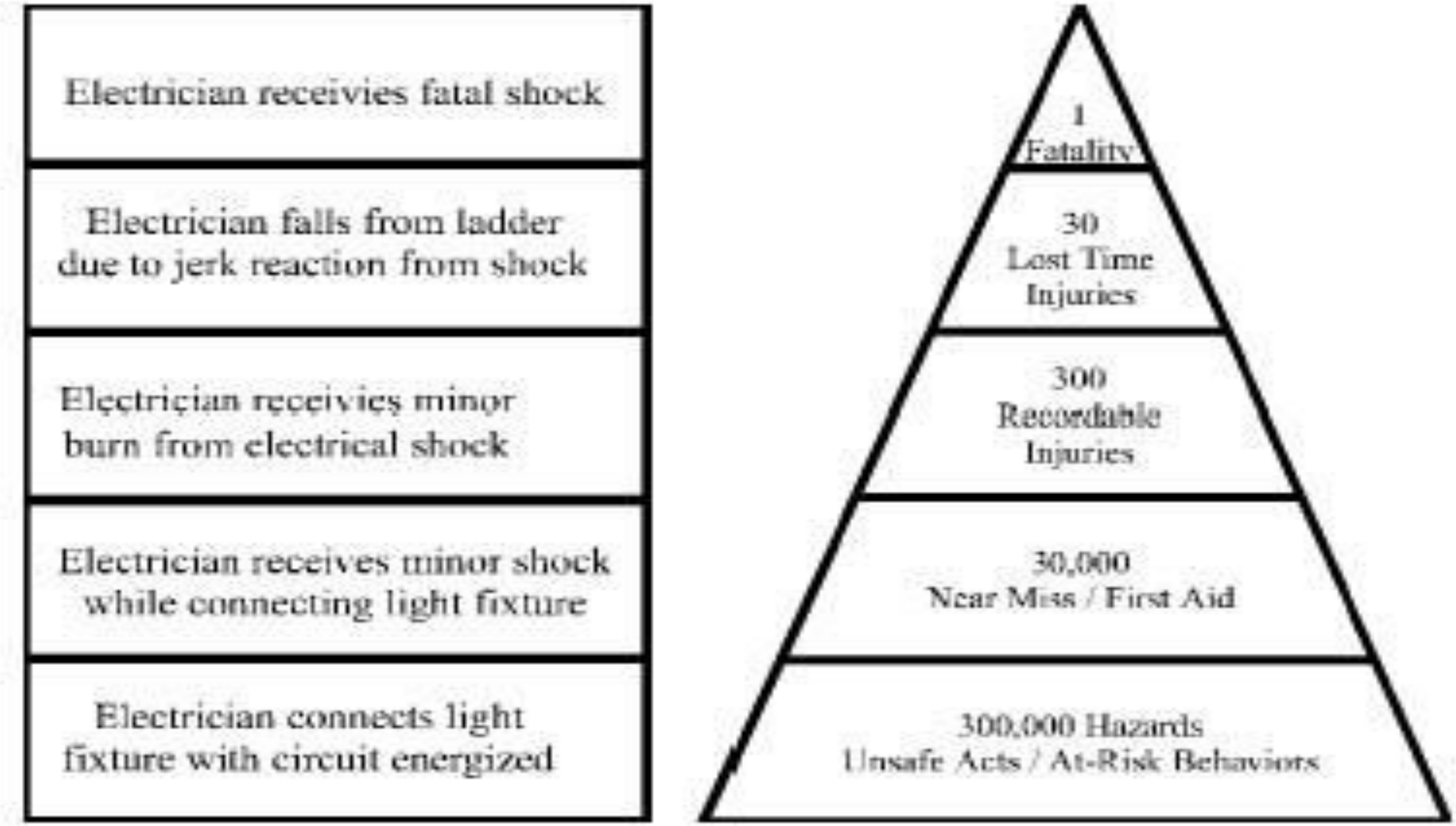


Introduction

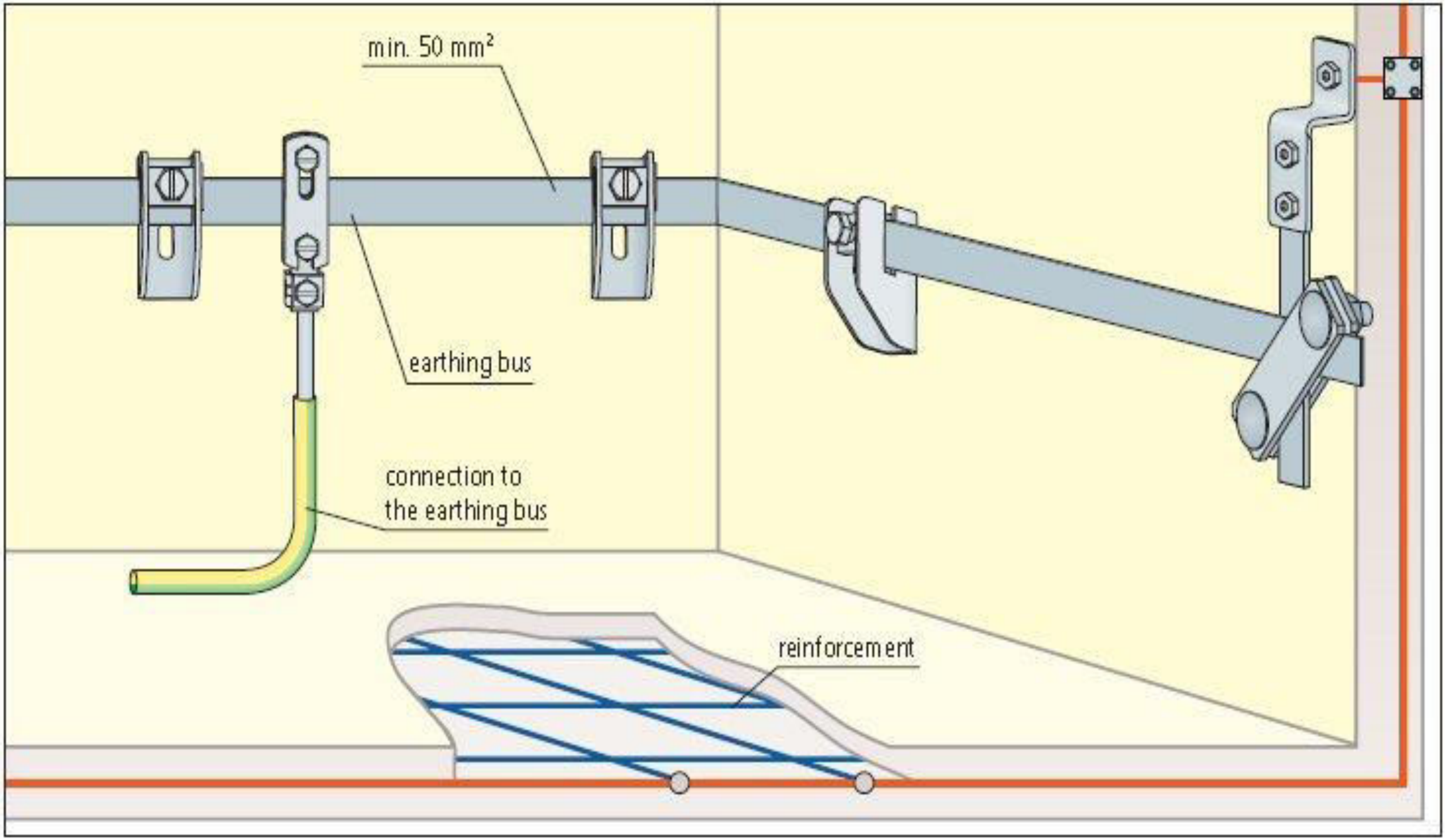
Earthing –Definition

- In electrical engineering, ground or earth is the reference point in an electrical circuit from which other voltages are measured, or is a common return path for electric current, or a direct physical connection to the Earth.

Electrical Hazards



Example


min. 50 mm²
earthing bus
connection to the earthing bus
reinforcement

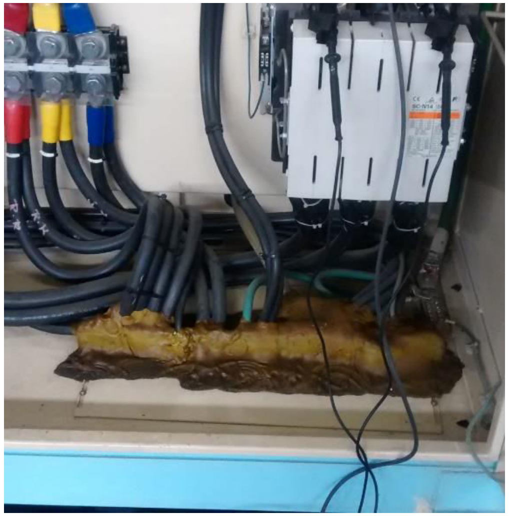
Wrong Practices in Plant

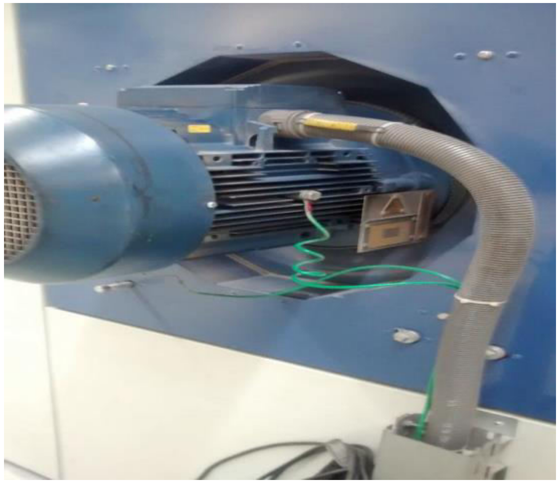
Earthing Wire Connected to Wrong Place

Wrong Practices in Plant

Lot of Joints in Earthing Strips

Good Practices in Plant





General Observations

- Earthing Plays Very important role in Plant Performance
- Schedule Testing of All earth Pits
- Earth pit should be isolate before testing
- Schedule maintenance of Earthing Pits
- Earth grids are not connected to each other
- All earth Pits should be connected to common grid
- GI/SS nut bolts should be used for connections
- Use Chemical earth pits

Observations Safety Mats

- Safety Mats should be as per new standard
- Rubber Mats old IS : 5424 /69
- New IS standard for Safety Mats IS:15652:2006
- New International Standard IEC 61111

To Sum up…

- Maintenance plays major role in keeping up the electrical system 24 x 7
- We can save lot of losses by maintaining the system well
- Electrical system failure create a lot of production and profitability loss

Thank you

Manpreet.singh@cii.in

09876724003

Confederation of Indian Industry

Welcome to

1st WORKSHOP

CAPACITY BUILDING OF LSPs UNDER GEF-UNIDO-BEE PROJECT "PROMOTING ENERGY EFFICIENCY AND RENEWABLE ENERGY IN SELECTED MSME CLUSTERS IN INDIA"

11 May 2018 **Nagaur**

CII Energy Management Services

Khalid Khan
Associate Counsellor – Energy Services
Accredited Energy Auditor
Confederation of Indian Industry
CII – Centre of Excellence for Competitiveness for SMEs

CII Energy Audit & Management

- **CII Energy Services:**
  - CII – Godrej Green Business Centre, Hyderabad
  - CII – Centre of Excellence for Competitiveness, Chandigarh for SMEs
  - CII – EMC, Chennai
  - CII – EMC, Ahmadabad
  - More than 100 experts involved in energy services
  - Team of Accredited & Certified Energy Auditors

CII Energy Audit & Management

- **Energy Services**
  - Detailed Energy Audit
  - Training Programs on Energy
  - Developing road map/benchmarking on Energy Consumption
  - Missions/workshops/seminars on energy
  - Audited more than 1500 units

CII Energy Audit & Management

❖ Major Initiatives & Projects

- ➲ World Class Energy Efficiency in Power Plant
- ➲ World Class Energy Efficiency in Sugar, Paper & Cement Sectors
- ➲ IREDA Project for Energy Efficiency in Textile sector
- ➲ Energy Audit of major DCs sector under PAT Scheme
- ➲ BEE – SME program for Energy Efficiency in SME sectors
- ➲ BEE – GEF – WB Faridabad Cluster
- ➲ Developed Manual on Energy Efficiency at Design Stage

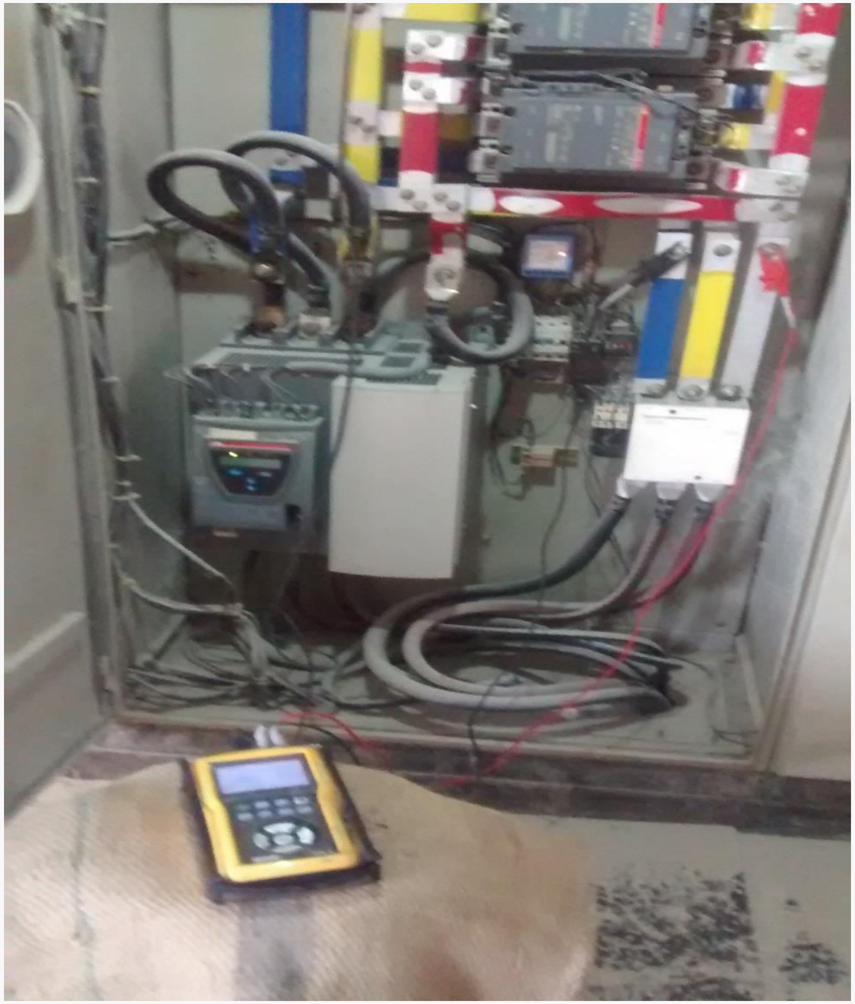
Energy Audit

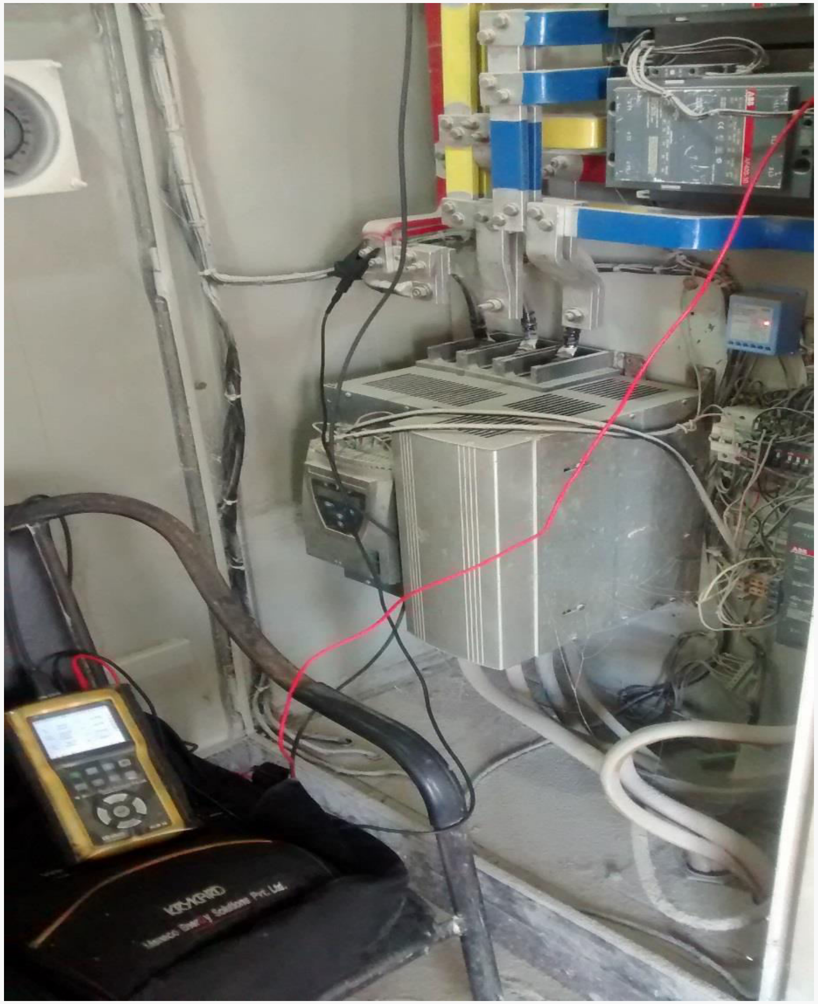
- **An energy audit –**
  - is an inspection, measurement survey and analysis of energy flows for energy conservation in an industry, building, process or system
  - to reduce the amount of energy input into the system without negatively affecting the output

List of Instruments used during Audit

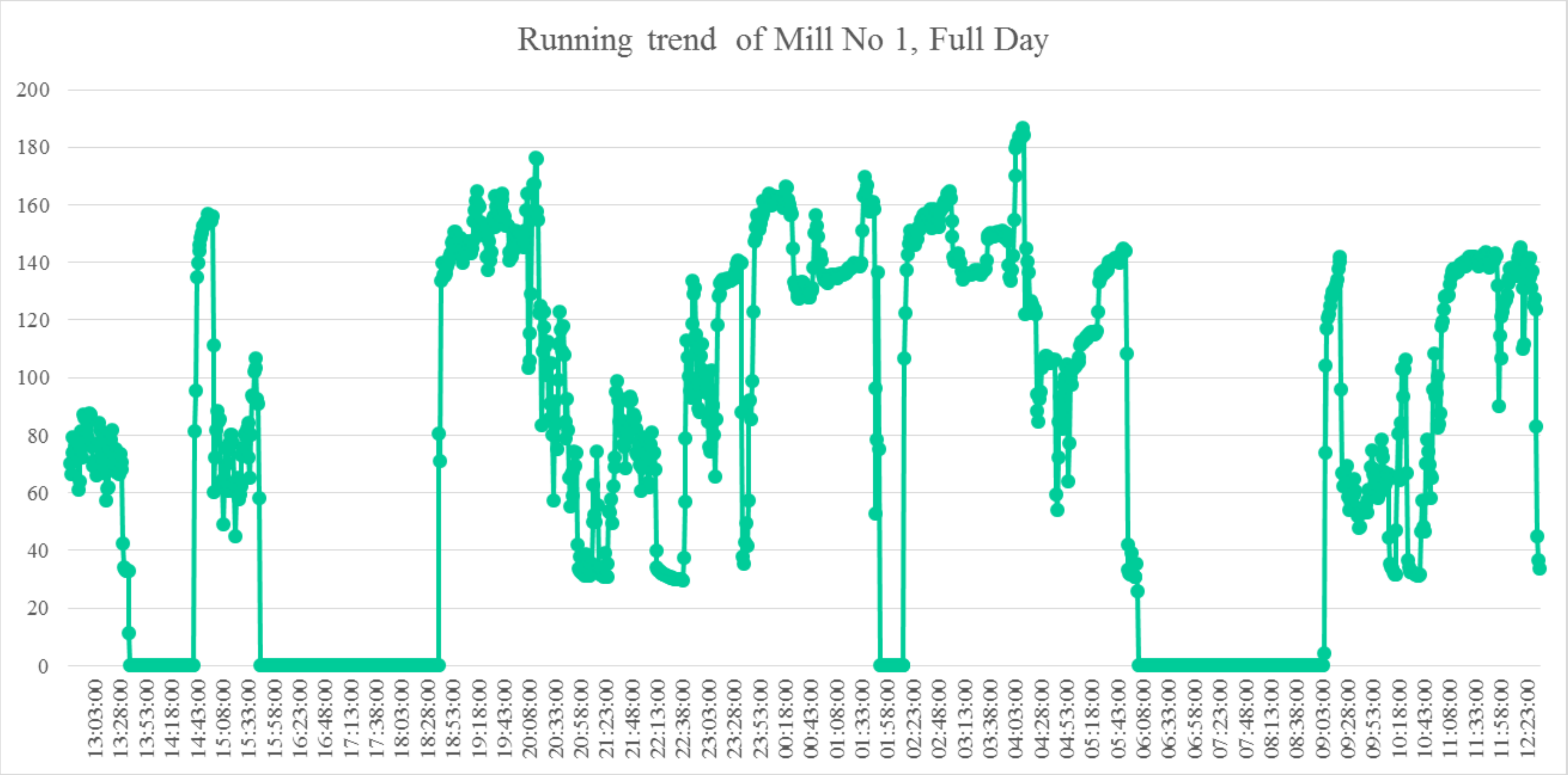
- Ultrasonic Flow Meter
- Power Analysers 3 Phase & 1 Phase
- Digital Pressure Gauges
- Thermal Imager
- Vane type anemometer
- IR Temperature Gun
- Lux meter
- Hygrometer

Installation of Power Meter

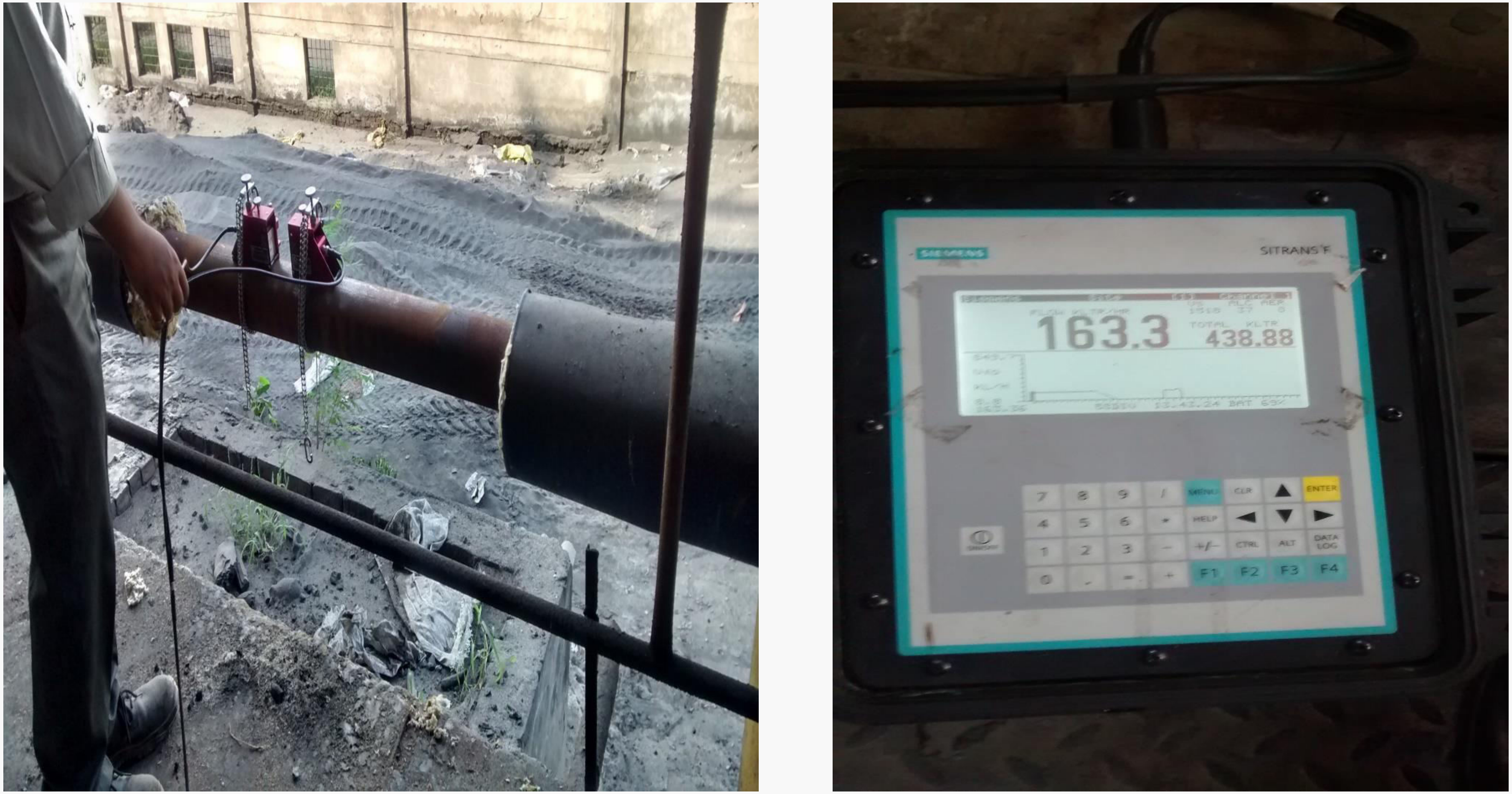




Equipment load pattern

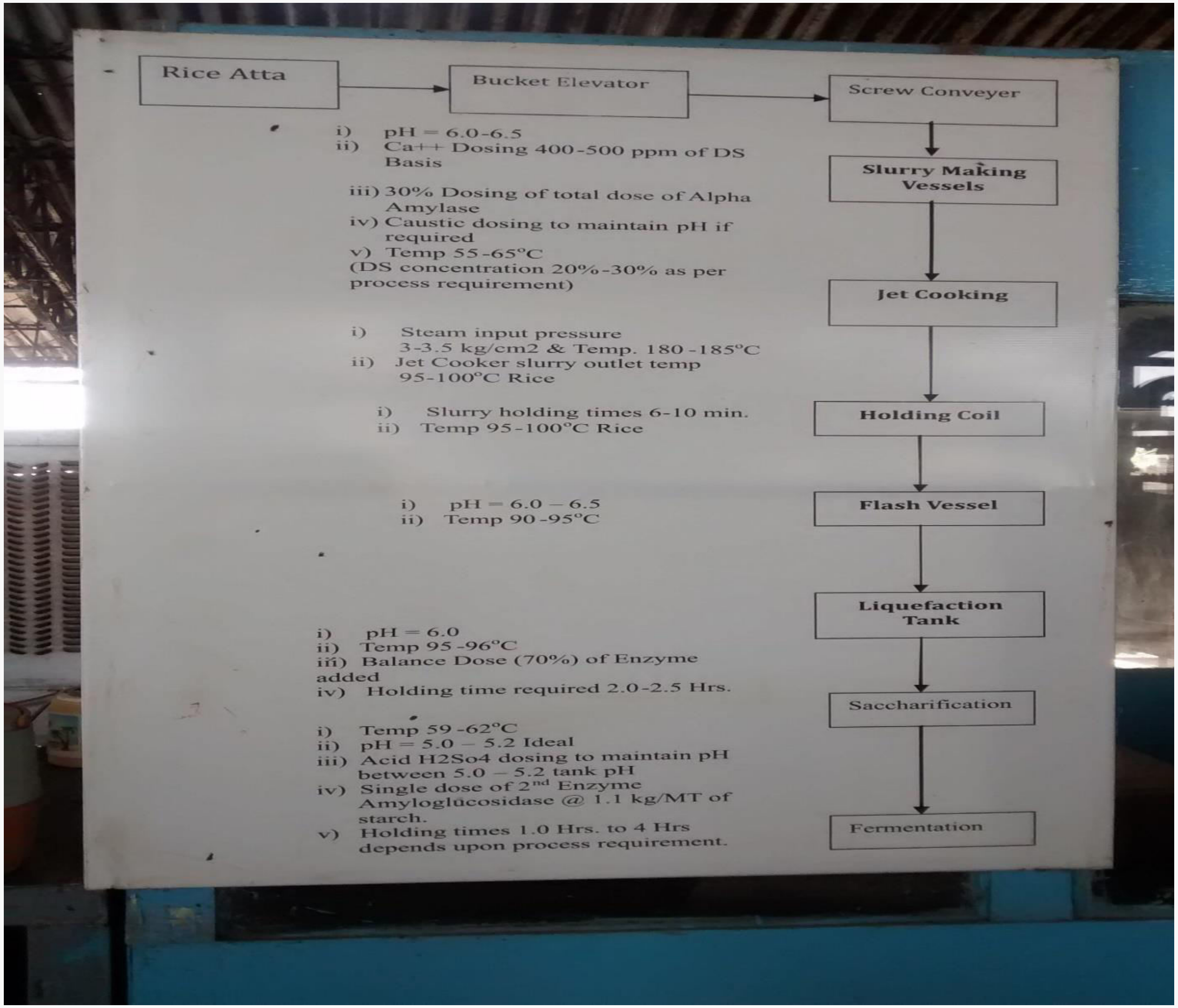


Installation of Flow Meter



Installation of Flue gas analyser

Process Flow Diagram



Rice Atta → Bucket Elevator → Screw Conveyer

Slurry Making Vessels

i) pH = 6.0-6.5
ii) Ca++ Dosing 400-500 ppm of DS Basis
iii) 30% Dosing of total dose of Alpha Amylase
iv) Caustic dosing to maintain pH if required
v) Temp 55-65°C
(DS concentration 20%-30% as per process requirement)

Jet Cooking

i) Steam input pressure 3-3.5 kg/cm2 & Temp. 180-185°C
ii) Jet Cooker slurry outlet temp 95-100°C Rice

Holding Coil

i) Slurry holding times 6-10 min.
ii) Temp 95-100°C Rice

Flash Vessel

i) pH = 6.0 – 6.5
ii) Temp 90-95°C

Liquefaction Tank

i) pH = 6.0
ii) Temp 95-96°C
iii) Balance Dose (70%) of Enzyme added
iv) Holding time required 2.0-2.5 Hrs.

Saccharification

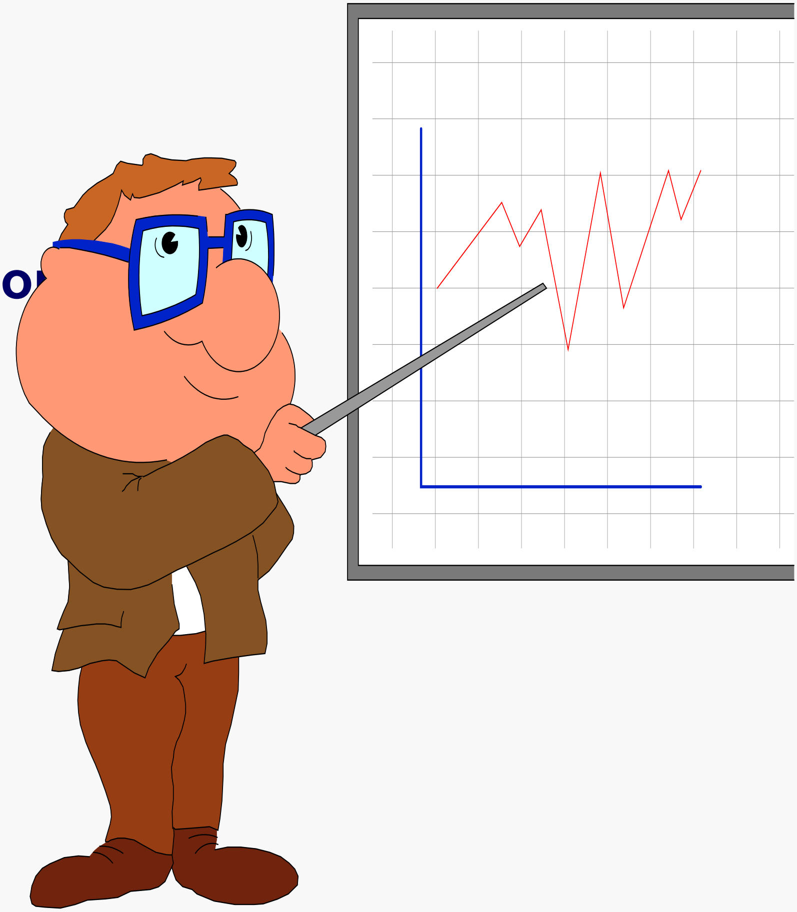
i) Temp 59-62°C
ii) pH = 5.0 – 5.2 Ideal
iii) Acid H2So4 dosing to maintain pH between 5.0 – 5.2 tank pH
iv) Single dose of 2nd Enzyme Amyloglucosidase @ 1.1 kg/MT of starch.
v) Holding times 1.0 Hrs. to 4 Hrs depends upon process requirement.

Fermentation

Energy Audit - Benefits

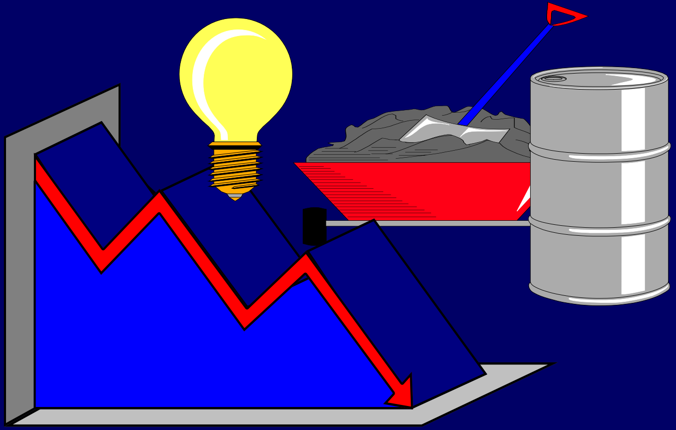
- Tangible Benefits
  - Reduction in energy consumption
  - Better control over quality
  - Savings in raw material consumption
  - Better equipment life
  - Reduced GHG emissions

- Intangible Benefits
- Plant expansion – designing of parameters
- Energy Efficient equipment purchase
- Alternate fuel/energy sources options
- Identification & feasible recommendation for critical issues



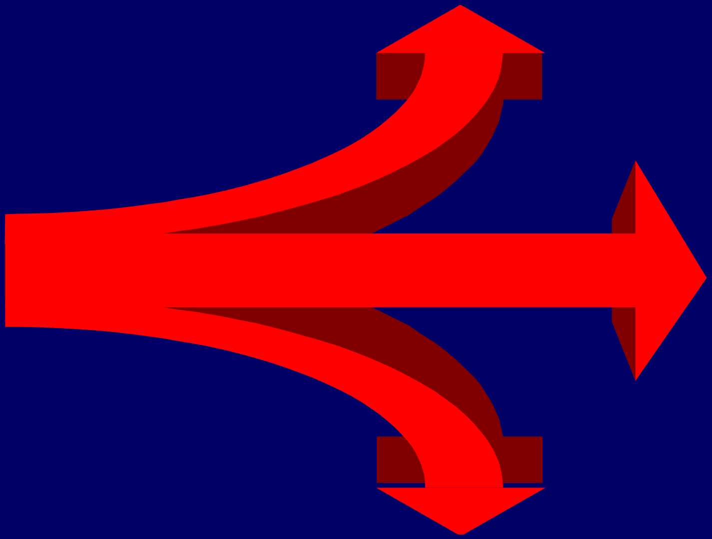
Energy Conservation at Macro Level

Measure of encon activities



Reduction in specific energy and Water consumption

Energy Conservation at Macro Level …



Capacity utilisation

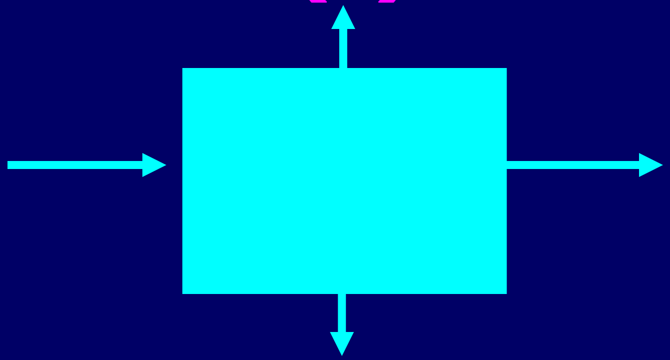
Three-pronged approach

Fine-tuning

Technology upgradation

Macro Level - Methodology

Any process/unit operation



Unavoidable losses

(c)

Energy input

(a)

Theoretical Requirement

(b)

(d)

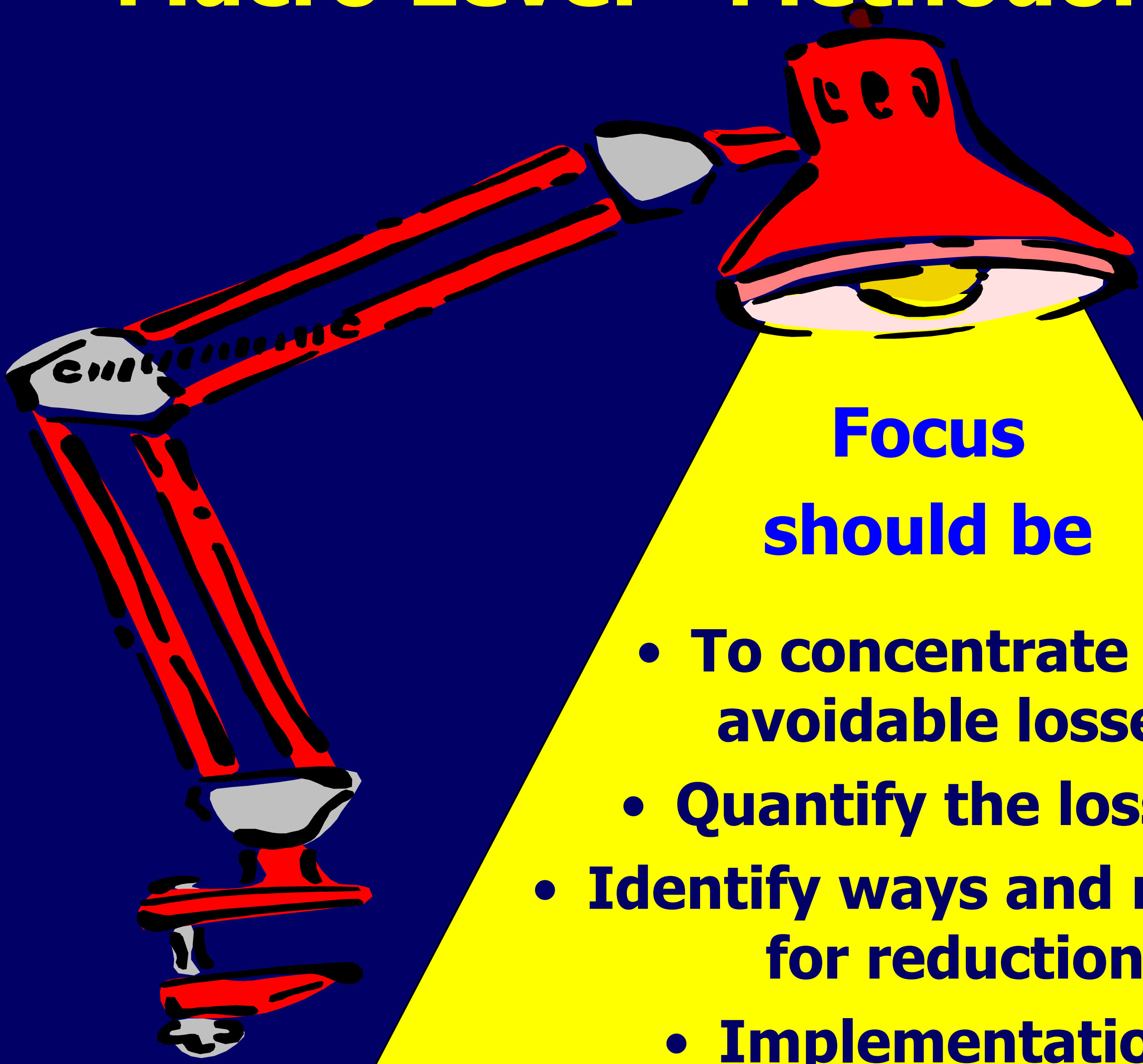
Avoidable losses

$$a = b + c + d$$

Losses – Avoidable Vs Unavoidable

- Pumps - Valve throttling control or Re-circulation
- Air Compressor leakage
- Compressed air generation pressure
- Furnace – Radiation losses
- Boiler – Flue gas losses
- Over designed equipments – Air Compressors, Fans & Blowers etc
- Condenser cooling water losses in Chillers etc

Macro Level - Methodology …



Focus

should be

- To concentrate on avoidable losses
- Quantify the losses
- Identify ways and means for reduction
- Implementation

Macro Level - Methodology

Losses – Two ways of representing

- There is compressed air leakage from 6 mm pipe in the plant
- Pump is operating at 40% valve throttling
- ID/FD fan being controlled by closing the damper
- Motor is under loaded
- Boiler flue gas temperature is 40 deg higher than recommended
- Specific Energy Consumption of Chiller is 0.15 kW/TR higher

Macro Level - Methodology

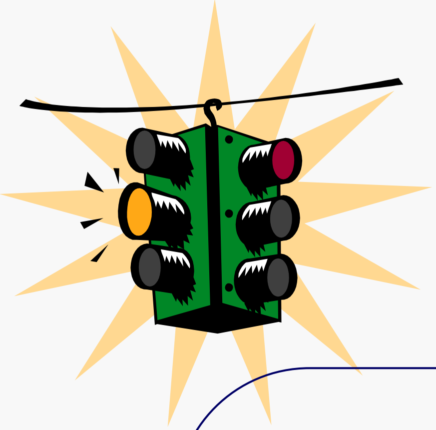
Losses – Two ways of representing

- There is compressed air leakage from 6 mm pipe in the plant which is costing Rs. 6.0 Lakhs/annum
- Pump is operating at 40% valve throttling – Consuming 40% extra power
- Blower flow is being controlled by closing the damper – consuming 5 kW more than requirement
- Motor is under loaded – potential to save Rs. 1.0 Lakhs/annum
- Boiler flue gas temperature is 40 deg higher than recommended - Costing around 2% extra fuel
- Specific Energy Consumption of Chiller is 0.70 kW /TR which is 0.15 kW/TR higher than the rated and costs Rs. 30 Lakhs/Annum for 300 TR Chiller

Macro Level - Methodology

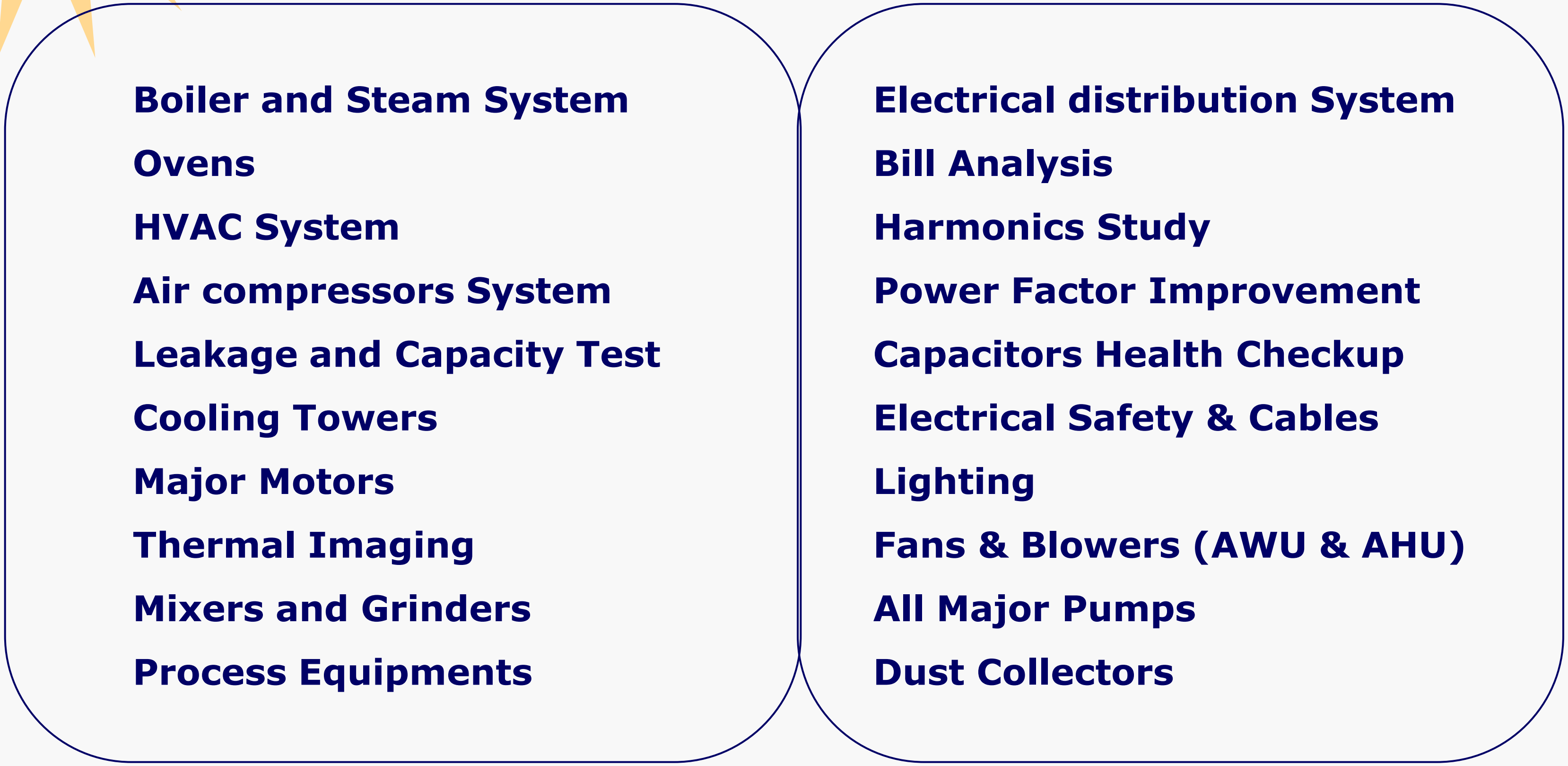
Identify ways and means for reduction -

- There can be 3 – 4 means of reduction
- Over designed pump -
  - Replacing with correct size
  - Impeller trimming
  - Speed control
  - Two pump system
- Decision depends on many factor – like cost, reliability, process etc



Coverage

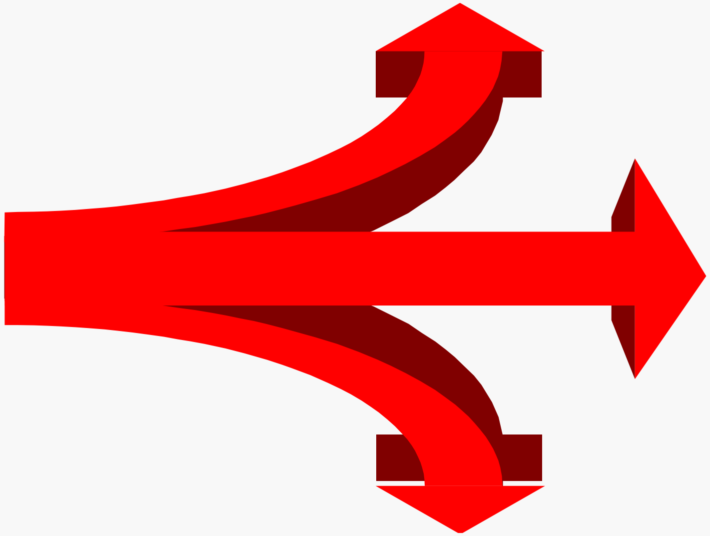
Thermal/Mechanical/Electrical



- **Boiler and Steam System**
- **Ovens**
- **HVAC System**
- **Air compressors System**
- **Leakage and Capacity Test**
- **Cooling Towers**
- **Major Motors**
- **Thermal Imaging**
- **Mixers and Grinders**
- **Process Equipments**

- **Electrical distribution System**
- **Bill Analysis**
- **Harmonics Study**
- **Power Factor Improvement**
- **Capacitors Health Checkup**
- **Electrical Safety & Cables**
- **Lighting**
- **Fans & Blowers (AWU & AHU)**
- **All Major Pumps**
- **Dust Collectors**

Three Pronged Approach



Detailed Energy Audit

Simple Projects
(< 6 months payback)

Medium term
(6-18 months payback)

Long term
(18-30 months payback)

Why energy saving?

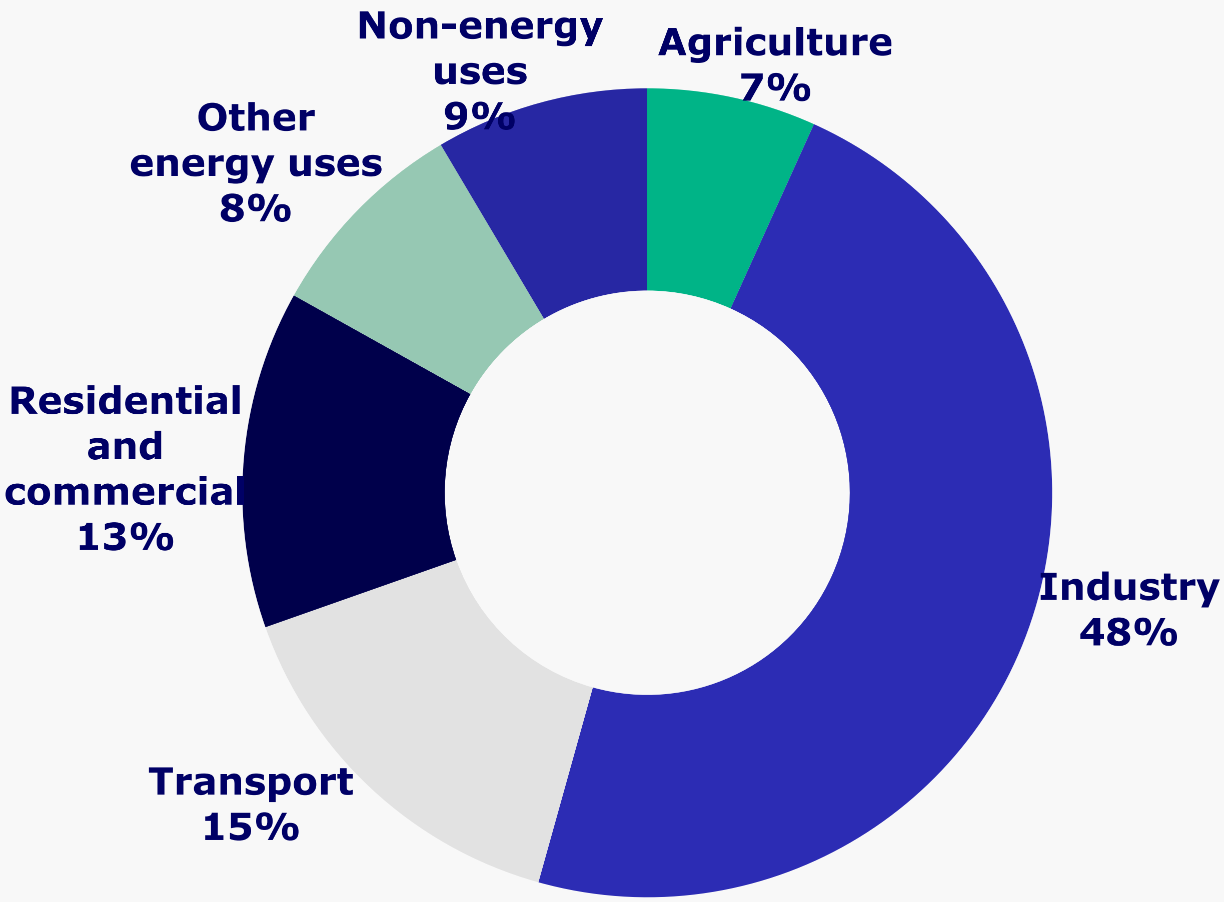
There have always been good reasons for energy saving

- CO2 reductions
- Environmental pollution
- Reduced operation costs

Two reasons force the market to act

- Legislation – worldwide and local
- Increasing energy costs

Commercial Energy Consumption Pattern in India



Energy conservation potential from various industries

	% Share of Energy Cost	Conservation Potential (%)
Iron and Steel	15.8	8-10
Fertilisers & Pesticides	18.3	10-15
Textile	10.9	20-25
Cement	34.9	10-15
Chlor-alkali	15.0	10-15
Pulp and Paper	22.8	20-25
Aluminium	34.2	8-10
Ferrous Foundry	10.5	15-20
Petrochemical	12.7	10-15
Ceramics	33.7	15-20
Glass	32.5	15-20
Refineries	1.0	8-10
Ferro-Alloys	36.5	8-10
Sugar	3.4	25-30

Energy Saving Opportunities

- **Industrial sector consumes about half of the total energy generation**
- **Energy can be saved up to 5 – 30 %**
  - **5 – 10 % of energy saving by following best operating practices**
  - **10 – 30 % of energy saving achieved by using energy efficient systems**

Summary of Audits-2016

S. No	Project name	Total Energy Bill (Rs. Lakhs)	Total Savings (Rs. Lakhs)	Average Cost Saving
1	Shri Ram Pistons & Rings Ltd Ghaziabad	9946	1465	15%
2	Rockman Industries Ltd, Ludhiana	1284	196	15%
3	Indeutsch Industries Pvt,Ltd Brush Division	168	46	27%
4	Orient Bell Limited	1857	384	21%
5	Virola Agra	135	40	30%
6	Honda Cars Ltd Tapukara	1868	247	13%
7	Sun Pharma Toansa	2207	464	21%
8	Dileep Industries	27	6	21%
9	Indeutsch Industries Pvt Ltd	141	28	20%
10	SRF Ltd	114	41	36%
11	Anmol Bakers	1117	217	19%
12	DSM	1103	231	21%

Summary of Audits-2016

S. No.	Project name	Total Energy Bill (Rs. Lakhs)	Total Savings (Rs. Lakhs)	Average Cost Saving
13	Samsonite	325	83	25%
14	Snam Alloys (Unit I) & (Unit II)	2428	205	8%
15	Snam Alloys, Pakala Mandal	5848	275	5%
16	Hotel Vibe by Lalit	117	15	13%
17	Star Mall	563	42	7%
18	Federal Mogul	6000	627	10%
19	Tasty Dairy	346	52	15%
20	Oswal Castings	686	82	12%
21	Lumax DK Auto Industries	367	115	31%
22	Somany Ceramics Pvt Ltd	6145	430	7%
23	Abhishri Packaging	365	105	29%
24	FMI Limited	405	96	24%
25	Godrej & Boyce Manufacturing Company Ltd	103	23	22%
	Total	43664	5514	13%
	Average			19%

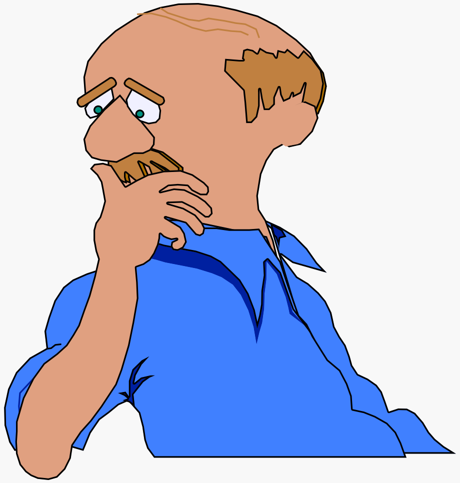
Summary of Audits-2017

S. No	Project name	Total Energy Bill (Rs. Lakhs)	Total Savings (Rs. Lakhs)	Average Cost Saving
1	Tiwana Oil Mills, Sirhind	313	85	27%
2	Mayur Leather Jaipur Plant-1	25	7	28%
3	Mayur Leather Jaipur Plant-2	29	7.25	25%
4	Federal Mogul Bhiwadi	353	139.32	39%
5	Hindustan Zinc Rampura Agucha	22326	679	3%
6	Uniproducts Rewari	1015	190.4	19%
7	Colgate Palmolive Sricity	643	196.21	31%
8	Cadbury Malanpur	1909	261.94	14%
9	IGEA Chandigarh	7027	1749.12	25%
10	TDI Kundli	796	110.24	14%
11	Piramal Glass, Gujarat	19810	390.9	2%
12	Baba Farid Institutions Bathinda	63	11.76	19%
13	Automat Industries	104	17.3	17%
14	Federal Mogul Parwanoo	604	243.6	40%

Summary of Audits-2017

S. No	Project name	Total Energy Bill (Rs. Lakhs)	Total Savings (Rs. Lakhs)	Average Cost Saving
15	IGEA Hoshiarpur	272	108.4	40%
16	Frick India Pvt Ltd Faridabad	357	53.1	15%
17	DEA Quardlife Sciences	208	42.59	20%
18	Mayur Uniquoters Jaipur-1	765	73.1	10%
19	Mayur Uniquoters Jaipur-2	919	88.12	10%
20	Anmol Steel, Kolkata	346	61.2	18%
21	NBC Newai	582	82.92	14%
22	NBC Manesar	347	94.5	27%
23	NBC Jaipur	8449	361.5	4%
24	NBC Vadodra	1060	130.63	12%
25	Minda Security Pune	155	24.9	16%
26	Lumax, Dharuhera	1455	296	20%
	Total	69932	5506	8%
	Average			20%

✓ 3 Major Factors



Equipment & Cost of Operation

Air Compressor

- 90 kW & 45 kW compressors in operation
- Present power consumption – 87 kW & 54 kW on loading
- Total power = 141 kW
- Running hrs = 24 hrs, 320 days/yr = 7680 hrs/yr, power cost Rs. 7.7/unit

Equipment & Cost of Operation

Cost Air Compressor Operation

- Cost of operation
- Energy Cost in 1 yr - Rs. 83.38 Lakhs
- Energy Cost in 10 yrs - Rs. 833.8 Lakhs
- Initial cost - Rs. 15.0 + 5.0 Lakhs
- Life of Comp - 10 yrs
- Maintenance cost - Rs. 1.0 Lakh/yr

Equipment & Cost of Operation

Life cycle cost of Dust collector blower

- **Total blower power - 40 kW**
- **Initial cost - Rs. 3.5 Lakhs**
- **Life of Blower - 10 yrs**
- **Maintenance cost - Rs. 0.5 Lakh/yr**
- **Energy Cost in 1 yr - Rs. 23.0 Lakhs**
- **Energy Cost in 10 yr - Rs. 230.0 Lakhs**

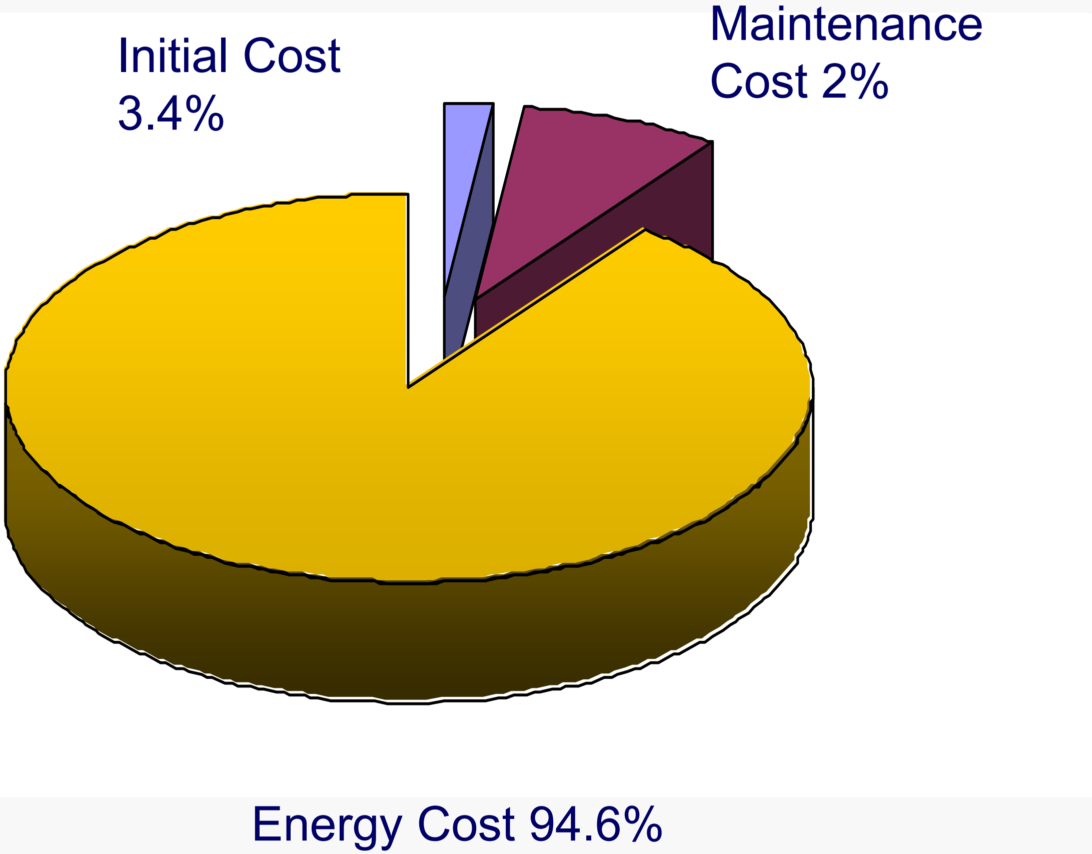
Equipment & Cost of Operation

Life cycle cost of Induction Furnace 1 T

- **Total power** - @ 600 units/T
- **Initial cost** - 60 Lakhs
- **Life of Furnace** - 10 yrs
- **Maintenance cost** - Rs. 5.0 Lakhs/yr
- **Energy Cost in 1 yr** - Rs. 280.0 Lakhs
- **Energy Cost in 10 yr** - Rs. 2800.0 Lakhs

I. Energy & Life cycle cost of an equipment

- **Energy Cost in 10 yrs- Rs. 833.8 Lakhs**
- **Initial cost - Rs. 30.0 Lakhs**
- **Life of Comp 10 yrs**
- **Maintenance cost - Rs. 10 Lakh/yr**



II. Equipment Efficiency & System Efficiency

Energy efficient system is the combination of best and most efficient components –

- system efficiency can be defined at different system levels

Energy Efficiency of Compressed Air System:

$$\eta_{air\ compressor\ system} = \eta_{generation} \ x\ \eta_{distribution} \ x\ \eta_{user}$$

$$\eta_{induction\ furnace} = \eta_{furnace\ type} \ x\ \eta_{control} \ x\ \eta_{electrical} \ x\ \eta_{Automation}$$

System efficiency – energy efficient equipment

may not work efficiently in a system !!!!

Example –

Furnace
Pump
Compressor
blower

III. Energy Monitoring & Targeting

- Measure to manage better!

Energy Monitoring and Targeting

Monitoring
To account for your energy use

Targeting
Assessing, setting & aiming for a particular consumption

- Help to eliminate waste & reduce energy use
- Provide the information required to make informed decisions
- Improve motivation
- Typical cost savings from a M&T programme are between 5-10%

Energy Monitoring

- Application of EMT
  - Predictive maintenance
    - Monitors major variation in operating parameters of equipment / Power consumption
  - Root cause analysis
    - Helps understanding energy wastage / idle operation of equipment
  - Measurement & Verification
    - Enables to access trends in energy usage in a facility
    - Verification of benefits achieved by implementation of energy conservation measures

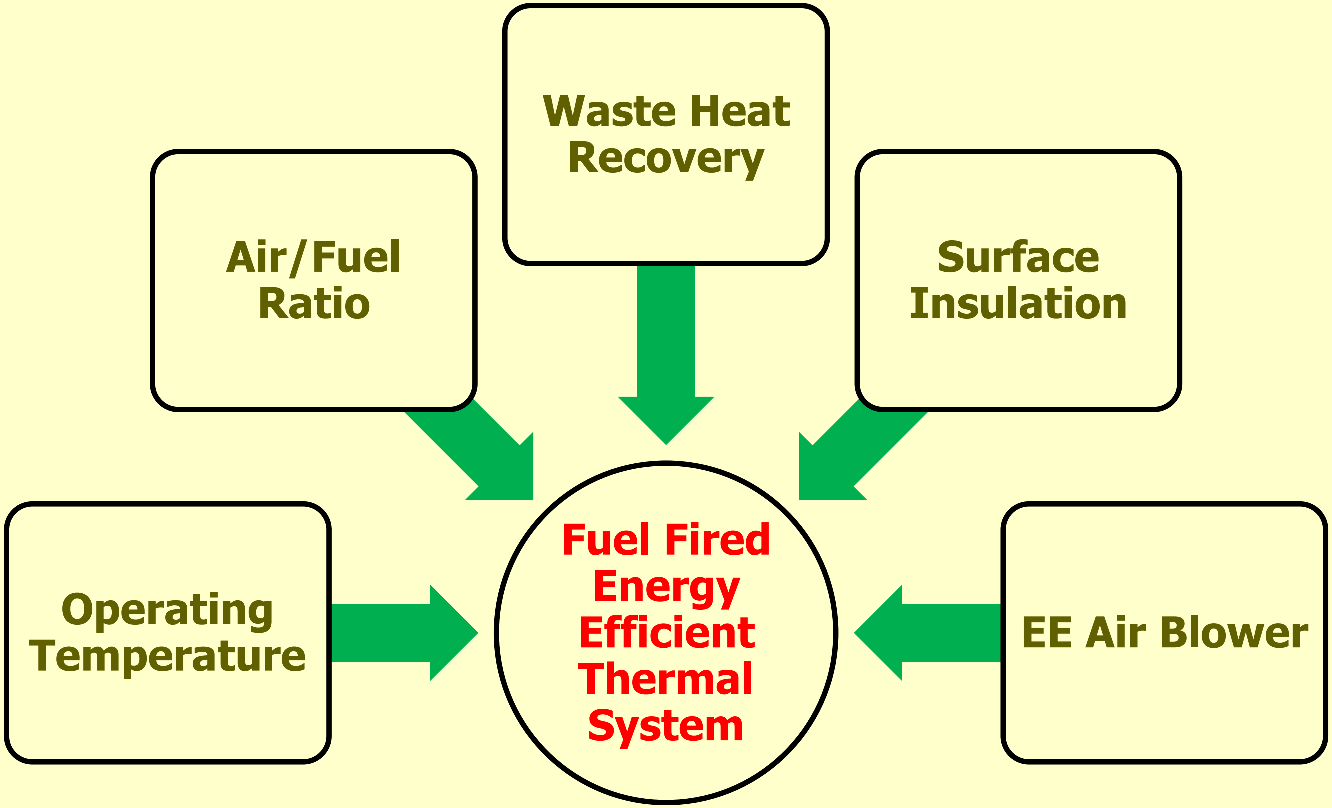
Thank You

Furnaces

Thermal Systems

- Furnaces
- Boilers
- Hot Water Generators
- Hot Air Generators
- Thermic fluid System
- Ovens

Energy Audit Approach



Waste Heat Recovery

Air/Fuel Ratio

Surface Insulation

Operating Temperature

Fuel Fired Energy Efficient Thermal System

EE Air Blower

Parameters affecting the performance

Operating Temperature

- Close to operational requirement
- Higher the temp. lower the efficiency & higher scale / metal loss
- For 12°C rise in temp. efficiency drops by 1% for furnace
- Every 4.8 kg/cm2 drop ⇒ 1% increase in efficiency

Parameters affecting the performance

Air/ Fuel Ratio

- Highly critical parameter
- Should be optimum

Air quantity for combustion -

An important parameter for energy efficiency

Exact air quantity

- Theoretical air requirement can be estimated from combustion theory
- Excess air required
- Quantity of excess air depends on mixing capability of fuel

- Mixing capability
  - Solid < Liquid < Gas
- Lesser the mixing capability
  - more the quantity of excess air

Basic principles of combustion

Fuel ingredients : C, H & S

$C + O_2 : CO_2$

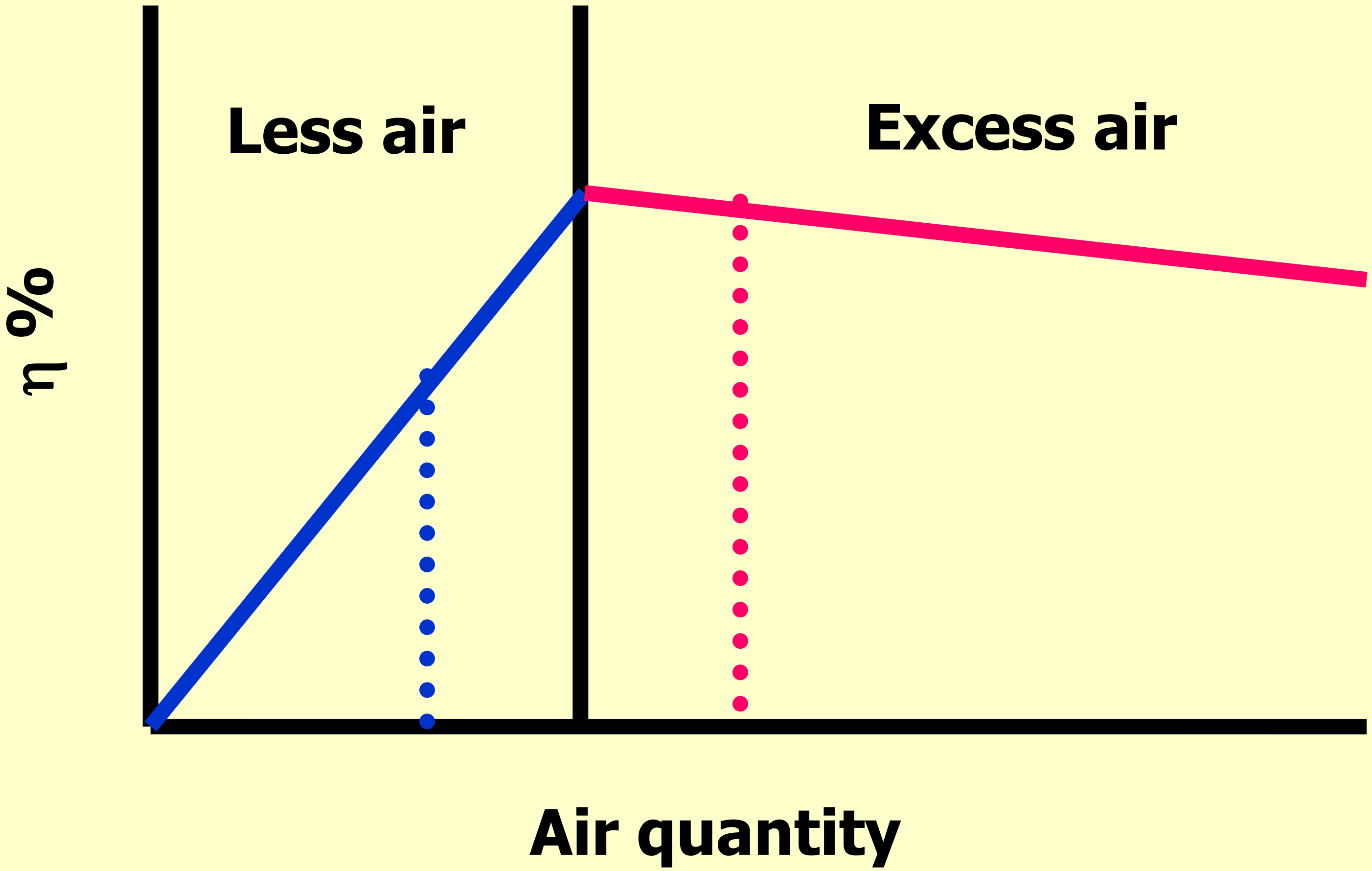
$2H_2 + O_2 : 2H_20$

$S + O_2 : SO_2$

Excess air %	Efficiency %
10	84.8
100	78.5
140	75.0

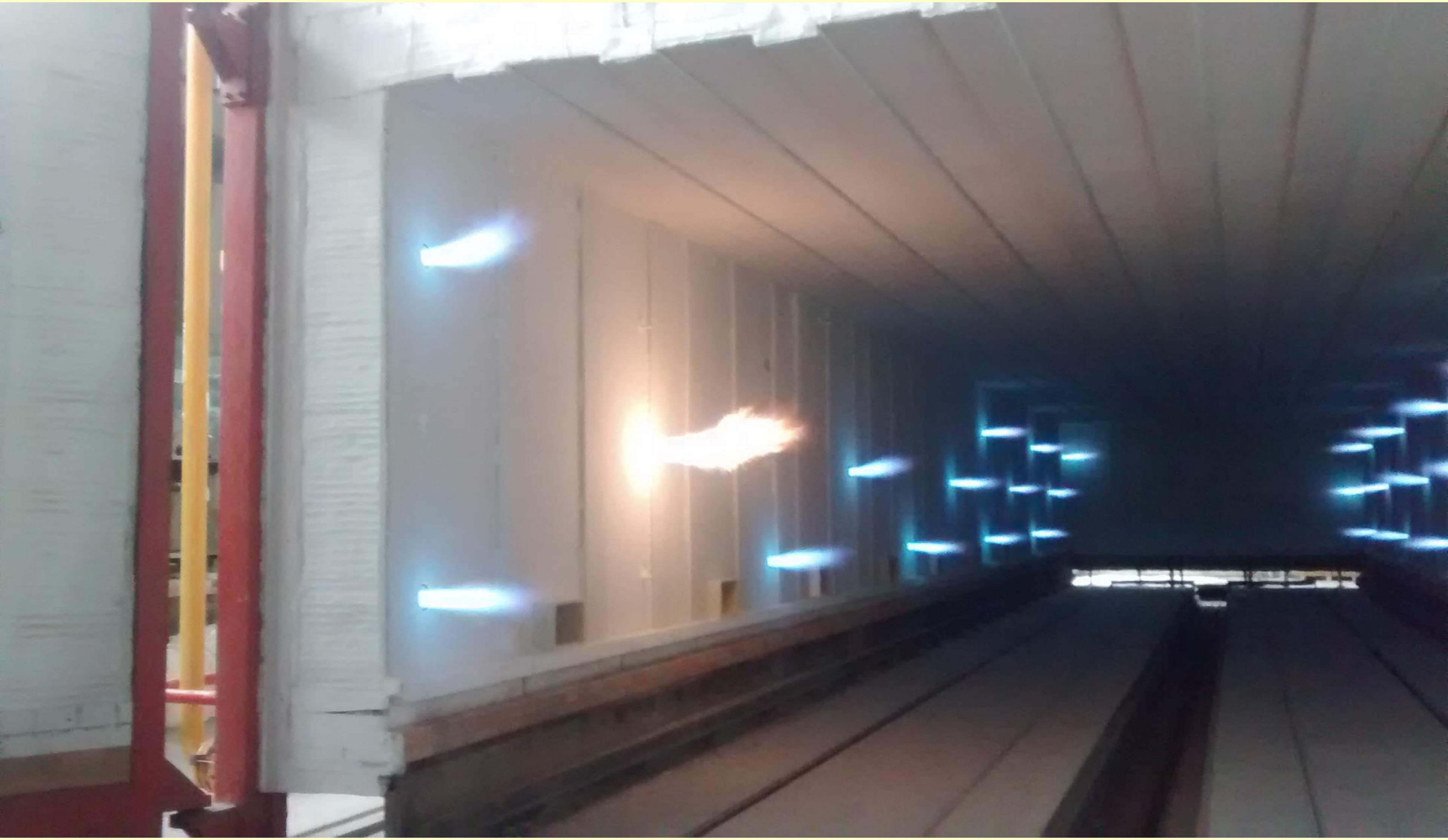
Keeping stack temperature constant

Effect of air quantity on efficiency



Effect of air quantity on efficiency

Effect of air quantity on efficiency



Parameters affecting the performance

Advance Energy Efficient Burners

Typical excess air requirements and resultant level of oxygen in flue gases

Coal	Oxygen %	Excess Air
Pulverised firing	4.0-5.0	20-30
Stoker firing	4.5-6.5	25-40
Fluidised bed combustion	4.0-4.5	20-25
Oil	1.0-3.0	5-15
Natural gas	1.0-2.0	5-10
Black liquor	1.0-2.0	5-10

Reduce excess air to optimal level

Instruments

- Portable combustion analyser
  - Merits & Demerits
  - Small size, multiple boilers

- On-line O_2 analyser
  - Large boilers (say, 70 TPH)
  - Location
  - Whether automatic?
- On-line CO/O_2 analyser with O_2 trim control
  - High capacity boiler

Flue gas temperature

- **High temperature**
  - Excess fuel firing
  - Fouled tubes (scaling inside/outside tubes)
- **Reasons for fouling**
  - Combustion particles deposition
  - Water treatment inadequate

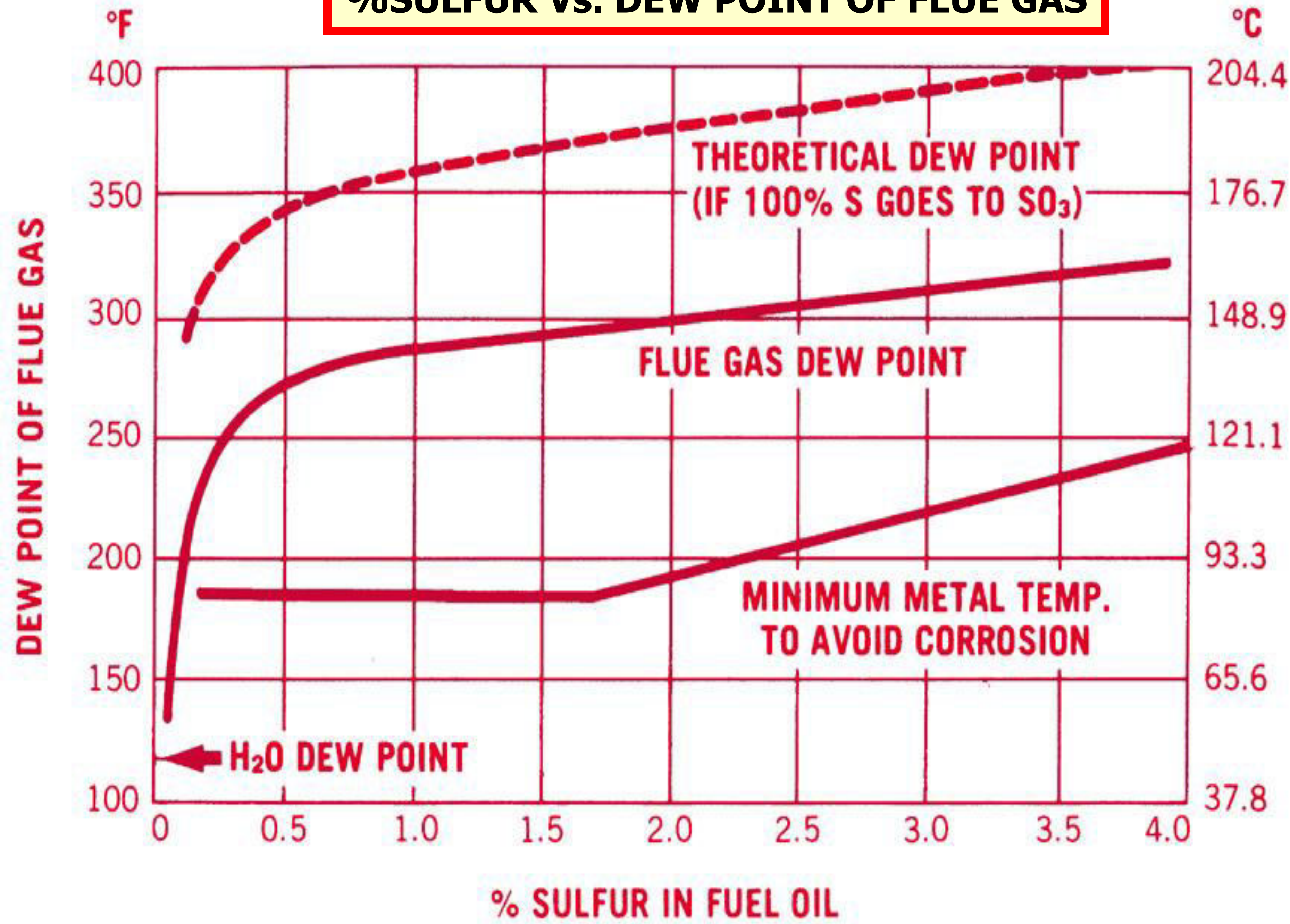
Every 22°C drop ⇒ 1% efficiency increase

Flue gas temperature

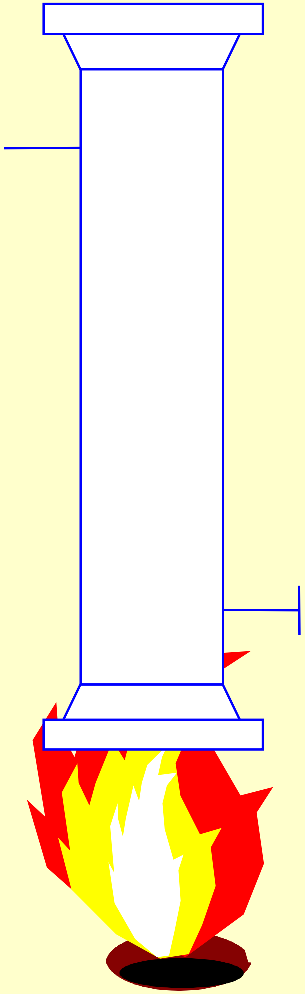
- Better to reduce exhaust temperature
- Lowest permissible exhaust temperature depends on Sulphur content in fuel
- For 1% Sulphur content in fuel
  - Recommended lowest exhaust flue gas temp. is about 150°C
  - For FO, LSHS and Coal

Reduce exhaust flue gas temperature to optimum levels

%SULFUR Vs. DEW POINT OF FLUE GAS



Parameters affecting the performance



Waste Heat Recovery

When do we recover waste heat?

- when exit temperature high
- when furnace runs on a continuous basis

Advantages of WHR

- reduction in fuel loss
- reduction in furnace heating time

Parameters affecting the performance

Surface Insulation- How important

- ✓ Adequate insulation-a must

What is the optimum surface temperature?

60 °C for thermal system

- ✓ Radiation Loss – Varies as fourth power of Temp

Radiation loss at 150 °C : 1500 Kcal/m2/hr

Radiation loss at 70 °C : 450 Kcal/m2/hr

Avoid the openings of furnaces to reduce radiation losses and leakages of combustion gas through openings

Optimize the Specific Energy Consumption of Tower and Skelner Furnaces

Present system

- Three fuel fired furnaces installed for melting
    - 2 Skelner Furnaces
        - 1 Ton & 1.5 Ton
    - 2 Tower Furnaces

- Furnaces are fired with Furnace Oil

Optimize the Specific Energy Consumption of Tower and Skelner Furnaces

Present system

- Operating Temperature
  - No monitoring system

- Air/ Fuel Ratio
  - No FO meters for individual furnaces
  - No proper control for air/ fuel ratio
  - Damper of combustion air controlled manually
  - Poor Burner Efficiency-Fuel Burning with orange flame

- Waste Heat Recovery –
  - Recuperator of Skelner furnaces not working properly
  - Temperature of combustion air is in range of 45-50 °C of all furnaces

Optimize the Specific Energy Consumption of Tower and Skelner Furnaces

Present system

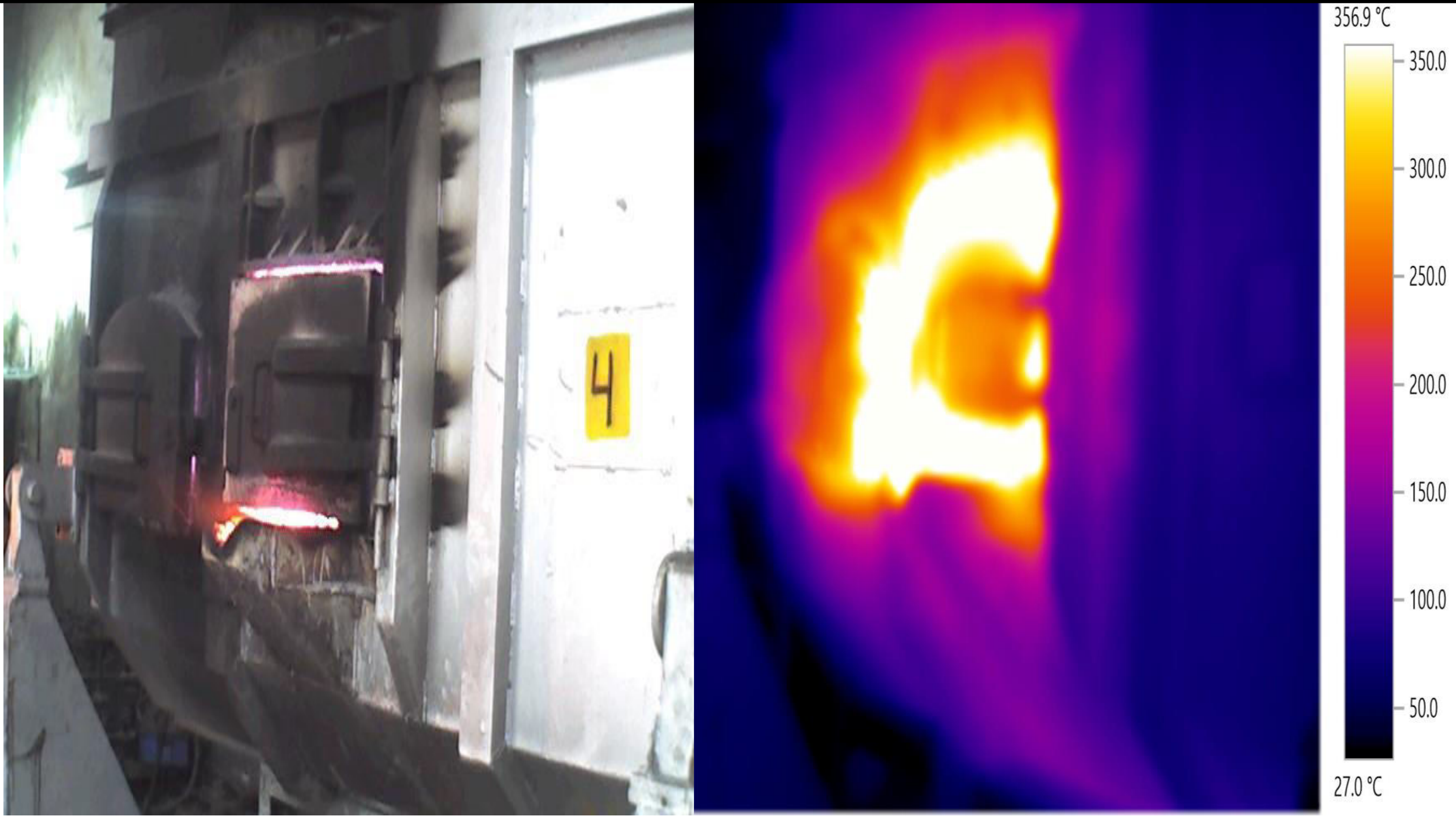
- Opening losses
  - Gates of furnaces have high opening, leading to high radiation losses
  - High positive pressure inside the furnaces
  - Hot combustion gas coming out of openings leading to energy and production loss

- Surface Insulation
  - Combustion Air line and recuperator of Skelner un-insulated
  - Combustion Air line of Tower Furnace is un-insulated
  - Surface Temperature of Tower furnace and Skelner Furnace is in range of 90-300 °C

Optimize the Specific Energy Consumption of Tower and Skelner Furnaces

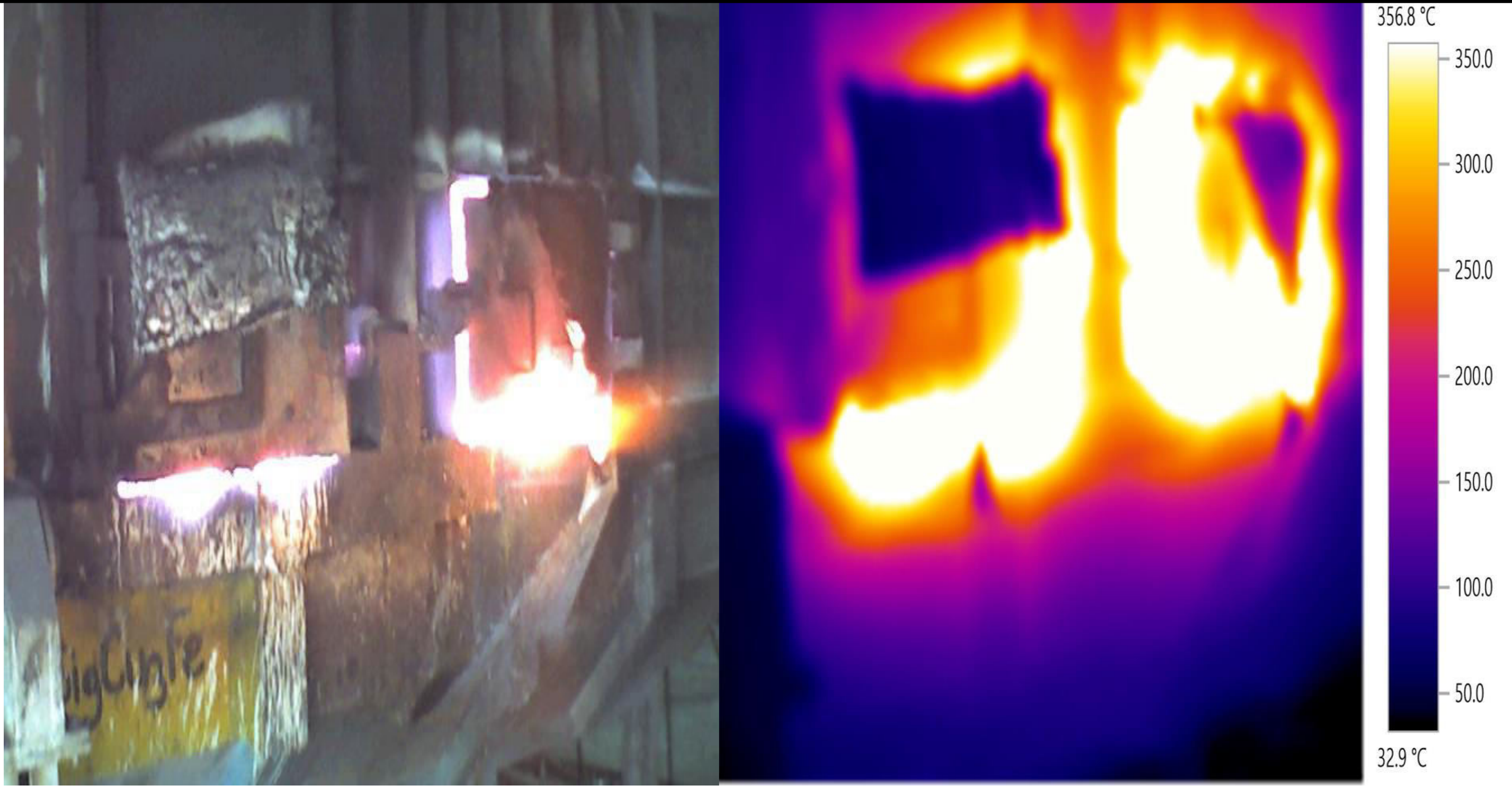
Opening Loss and Combustion gas loss
Skelner Furnace

Optimize the Specific Energy Consumption of Tower and Skelner Furnaces



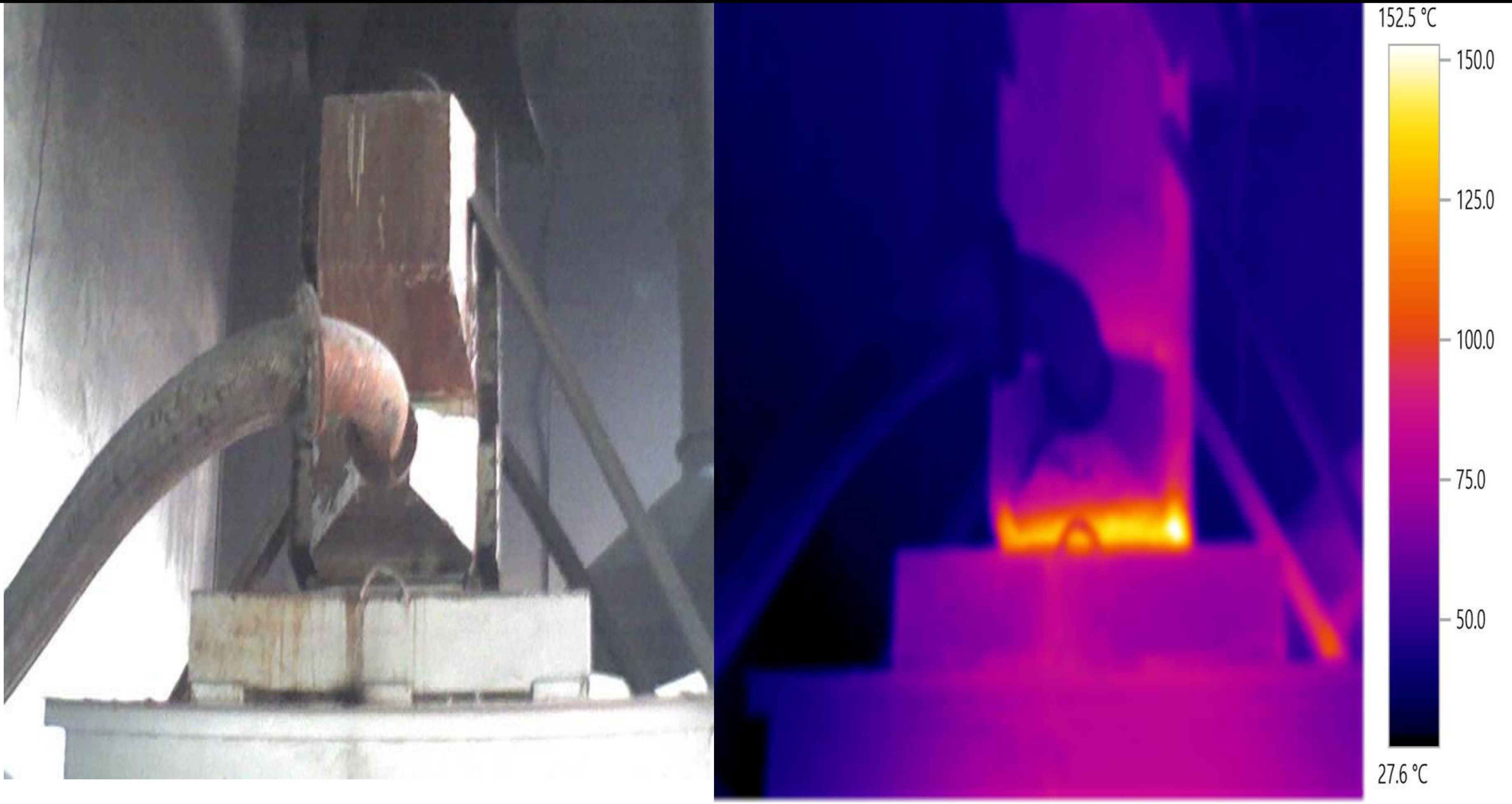
Skelner Furnace

Optimize the Specific Energy Consumption of Tower and Skelner Furnaces



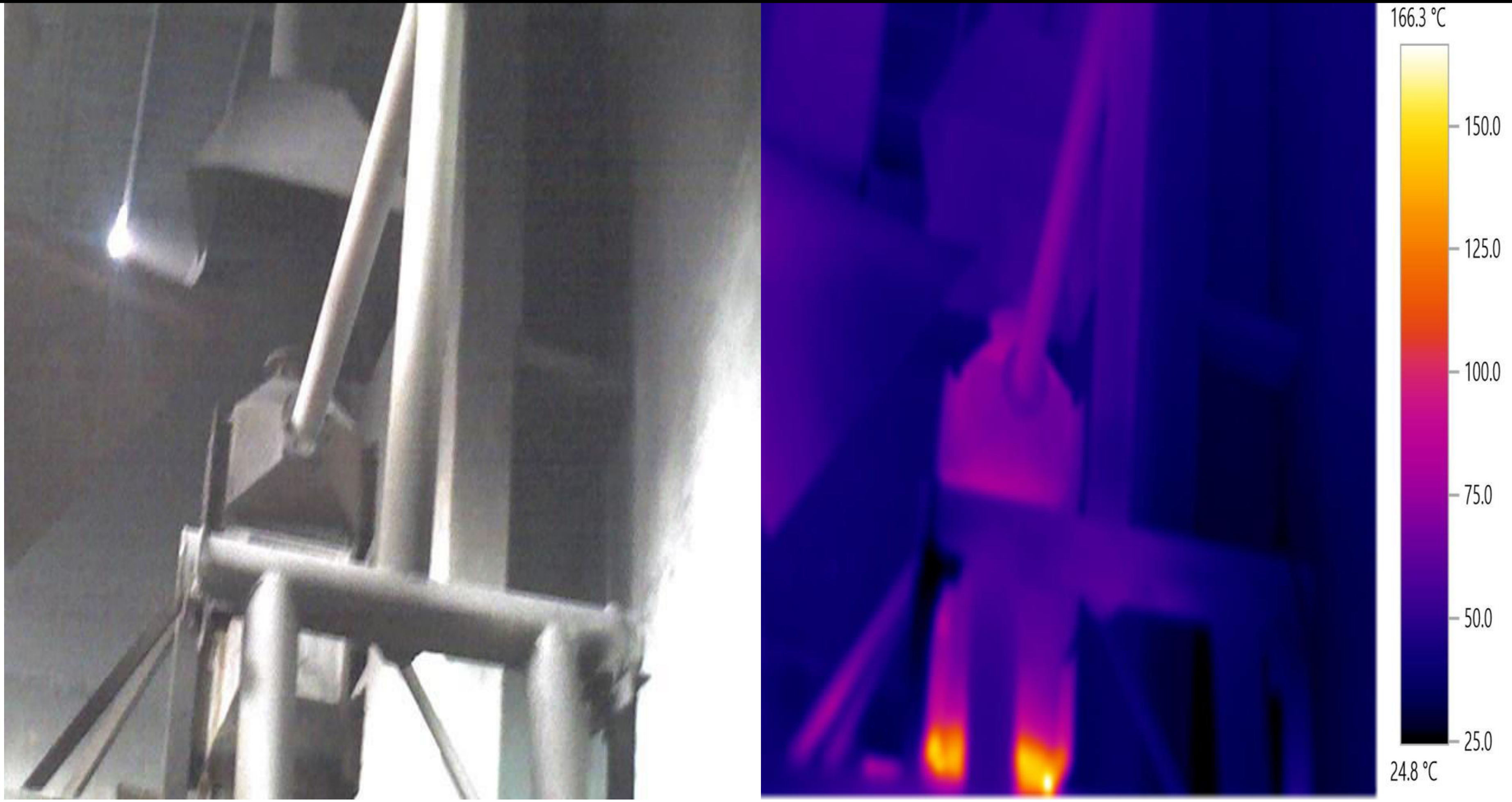
Skelner Furnace

Optimize the Specific Energy Consumption of Tower and Skelner Furnaces



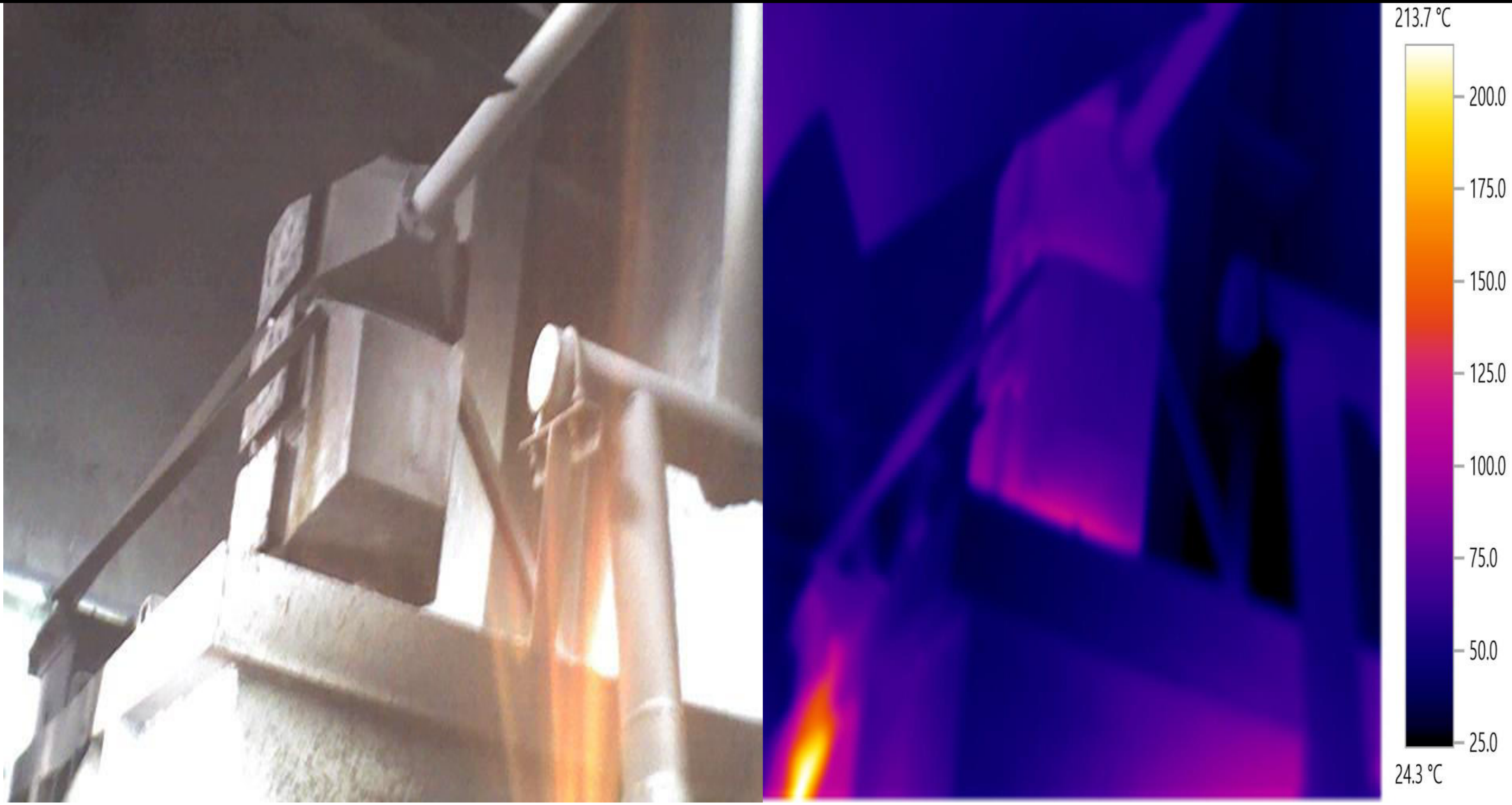
Recuperator Skelner Furnace

Optimize the Specific Energy Consumption of Tower and Skelner Furnaces



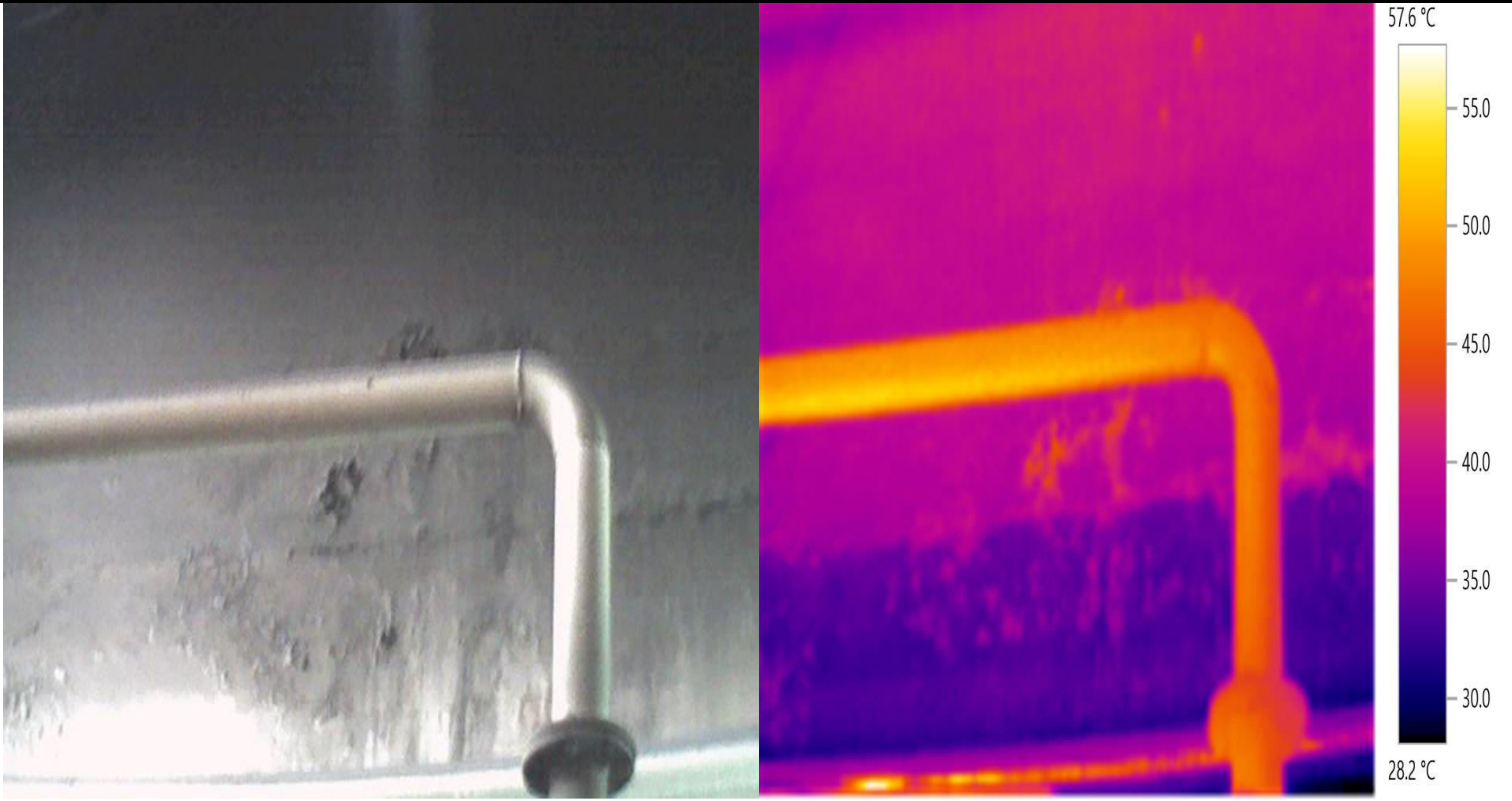
Recuperator Skelner Furnace

Optimize the Specific Energy Consumption of Tower and Skelner Furnaces



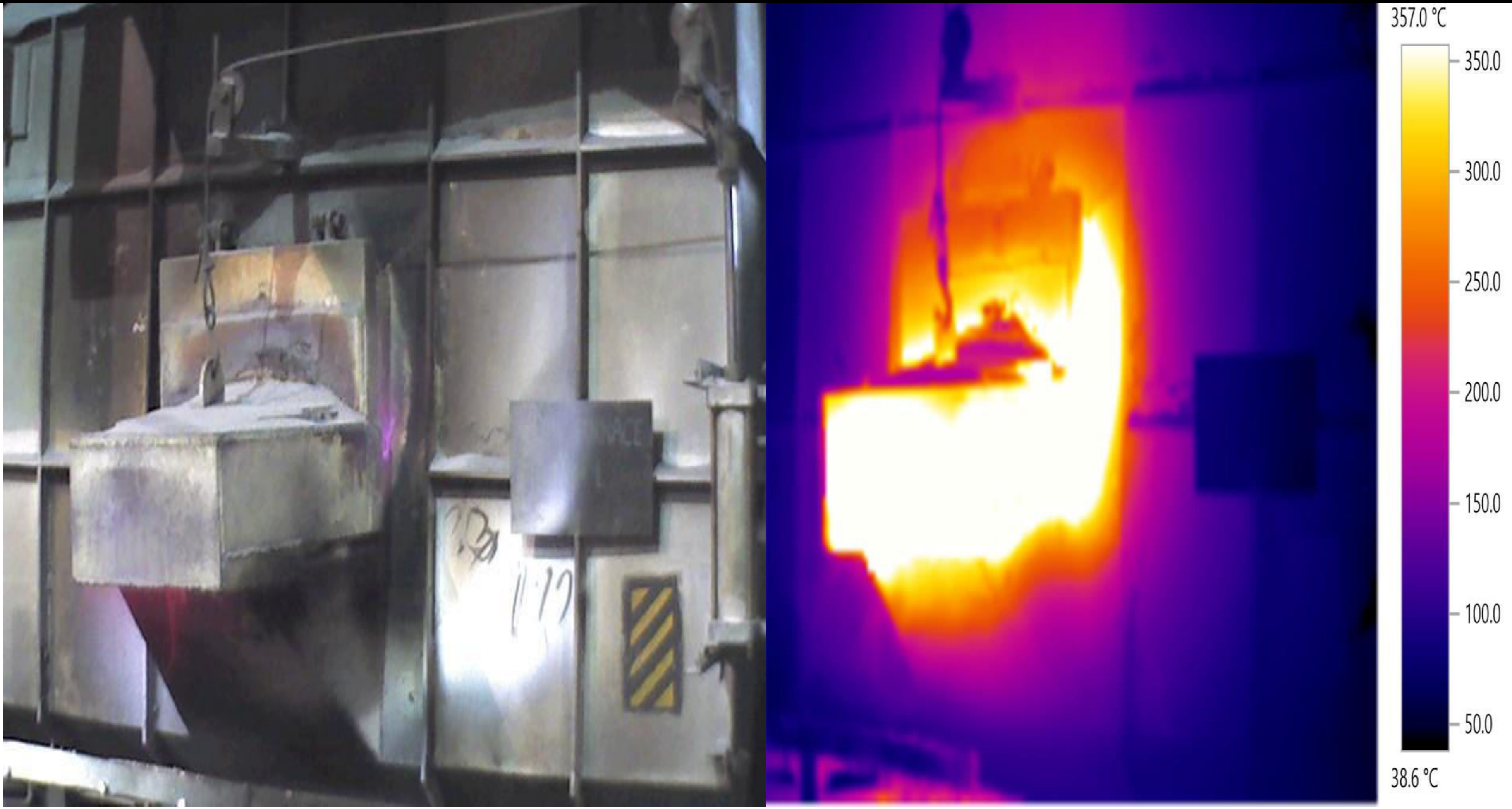
Recuperator Skelner Furnace

Optimize the Specific Energy Consumption of Tower and Skelner Furnaces



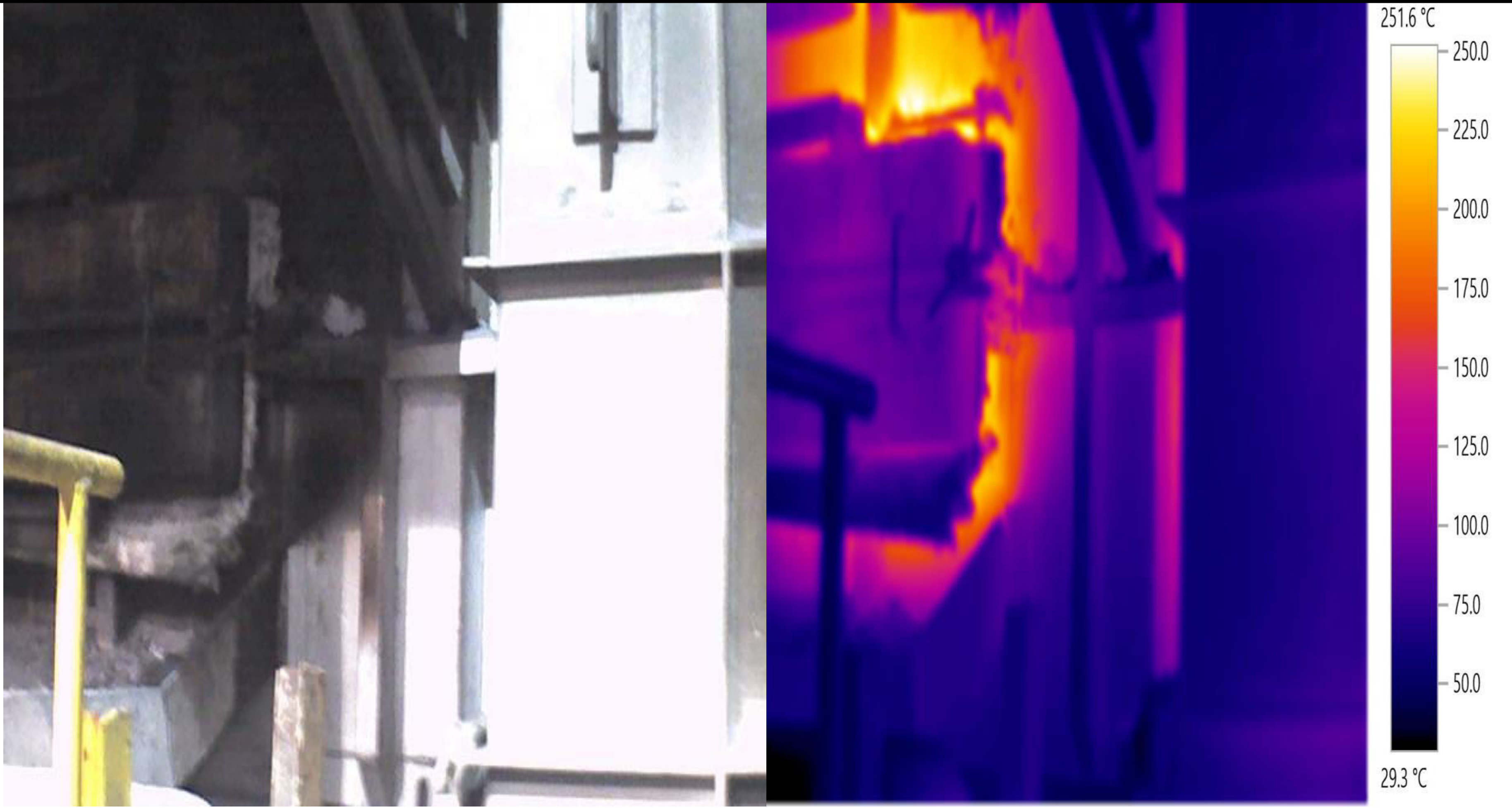
Combustion Air Line-Skelner Furnace

Optimize the Specific Energy Consumption of Tower and Skelner Furnaces



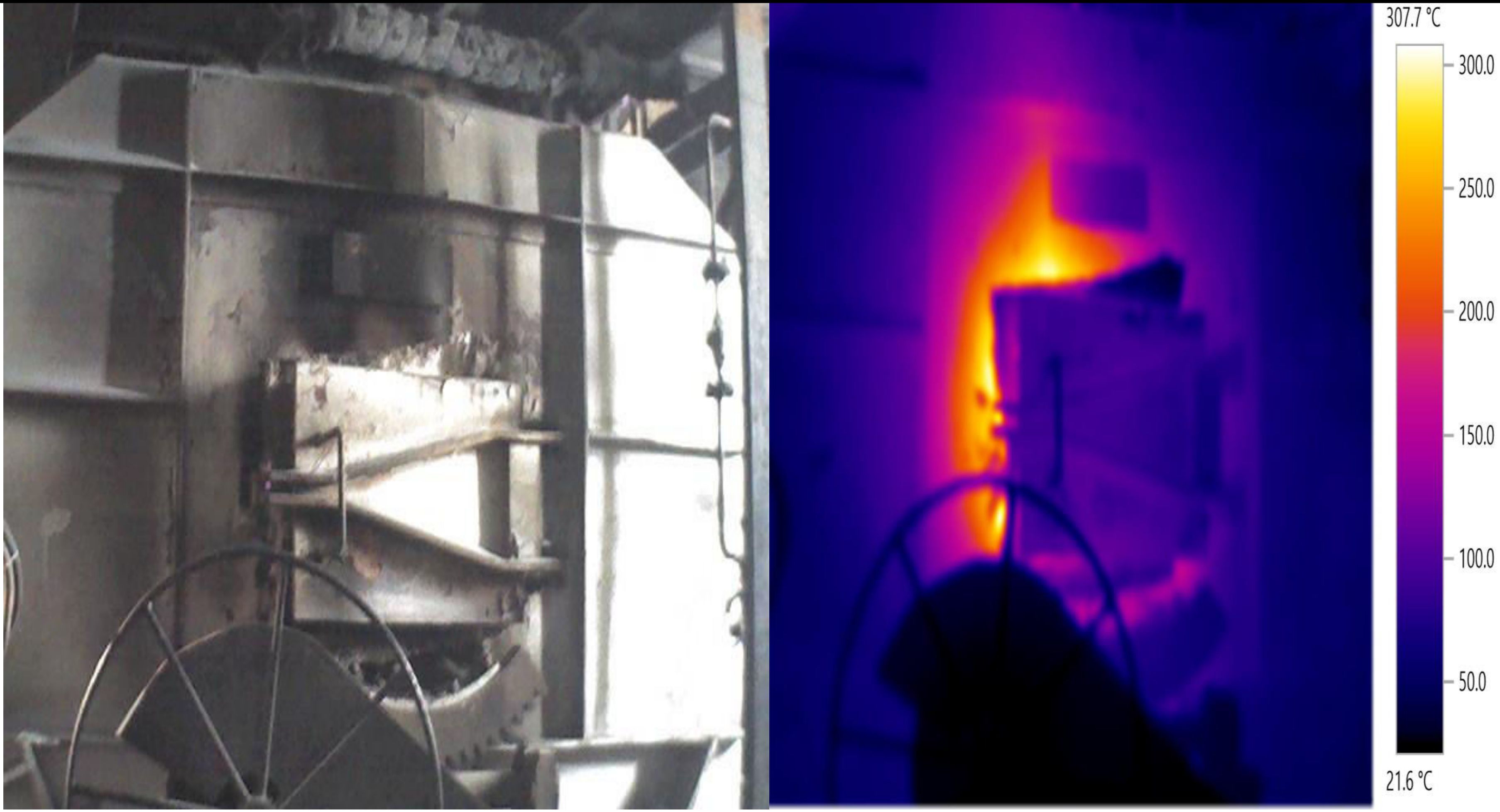
Tower Furnace Front

Optimize the Specific Energy Consumption of Tower and Skelner Furnaces



Tower Furnace

Optimize the Specific Energy Consumption of Tower and Skelner Furnaces



Tower Furnace Side

Optimize the Specific Energy Consumption of Tower and Skelner Furnaces

Specific Fuel Consumption in Furnace

Theoretical Value of Heat required – M x Cp x ▲ T

Mass - 1000 kG
Specific Heat Cp of Al - 0.22 kcal/kg Deg C
Temp Rise - 730-30 = 700 Deg C
Heat Reqd. - 154000 kcal/tonne

Efficiency of Furnace - 25-35 %
Heat Reqd. @ 25% Eff - 616000 kcal/tonne
Fuel required @ GCV 10000 kCal/kg = 61.6 kG/Tonne

Heat Reqd. @ 35% Eff - 440000 kcal/tonne
Fuel required @ GCV 10000 kCal/kg = 44 kG/Tonne

Optimize the Specific Energy Consumption of Tower and Skelner Furnaces

On Tower Furnace (DEC 15)			
Material Molted (Ton)	**FO Used (Kg)**	**SEC (kg/Ton)**	**Efficiency % age**
782.926	57844	73.88	21 % approx.

On Skelner Furnace (DEC 15)			
Material Molted (Ton)	**FO Used (Kg)**	**SEC (kg/Ton)**	**Efficiency % age**
285.953	27300	95.47	16 % Approx.

Optimize the Specific Energy Consumption of Tower and Skelner Furnaces

Action Plan

- Install temperature sensors on all Furnace & avoid overshooting of temp.
- Replace existing burners with Modulation burners for maintaining A/F ratio
- Use VFD on combustion Air blower in place of damper
- Proper Utilize Recuperator of Skelner furnaces
- Reduce openings to minimum

Optimize the Specific Energy Consumption of Tower and Skelner Furnaces

Action Plan

- Install recuperator on tower furnace to Preheat combustion air
- Pre Heat FO day tank for efficient combustion and control its temperature up to 100 Deg. C
- Improve surface insulation
  - Insulate FO line and combustion air flow line
  - Use insulation paints on Furnaces
- Install weighing balance close to furnace to avoid temperature drop of molten metal

Optimize the Specific Energy Consumption of Tower and Skelner Furnaces

Potential Saving > 25 - 30 %
Saving Calculation = 15% of Total Annual FO bill

Annual Savings - Rs. 19.50 Lakhs
Investment - Rs. 10.00 Lakhs
Payback - 6 Months

Furnaces Operating Costs

Present Analysis –

Unit I			
S N	**Parameters**	**Units**	**Figures**
1	Fo Consumption	Litres/Day	80
1	FO Cost	Rs./Kg	33
3	Plant Running hours	Hours/Day	6
4	Plant Running days	Days/Annum	300
5	Weight of Product	gm	250
6	Average Production	Pieces/Day	1500
7	Specific Energy Consumption	Liters/Ton	187

Furnaces Operating Costs

Present Analysis –

Unit II			
S N	**Parameters**	**Units**	**Figures**
1	Fo Consumption	Litres/Day	70
1	FO Cost	Rs./Kg	33
3	Plant Running hours	Hours/Day	6
4	Plant Running days	Days/Annum	300
5	Weight of Product	gm	250
6	Average Production	Pieces/Day	1500
7	Specific Energy Consumption	Liters/Ton	186

Furnaces Operating Costs

Present Analysis –

Unit III			
S N	**Parameters**	**Units**	**Figures**
1	Fo Consumption	Litres/Day	80
1	FO Cost	Rs./Kg	33
3	Plant Running hours	Hours/Day	6
4	Plant Running days	Days/Annum	300
5	Weight of Product	gm	290
6	Average Production	Pieces/Day	1700
7	Specific Energy Consumption	Liters/Ton	162
8	Specific Energy Consumption (Recommended)	Liters/Ton	72
9	Saving Potential	Rs./Year	5,00,000

Furnaces Operating Costs

Annual Savings - Rs. 5.00 Lakhs

Thank You

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Motors

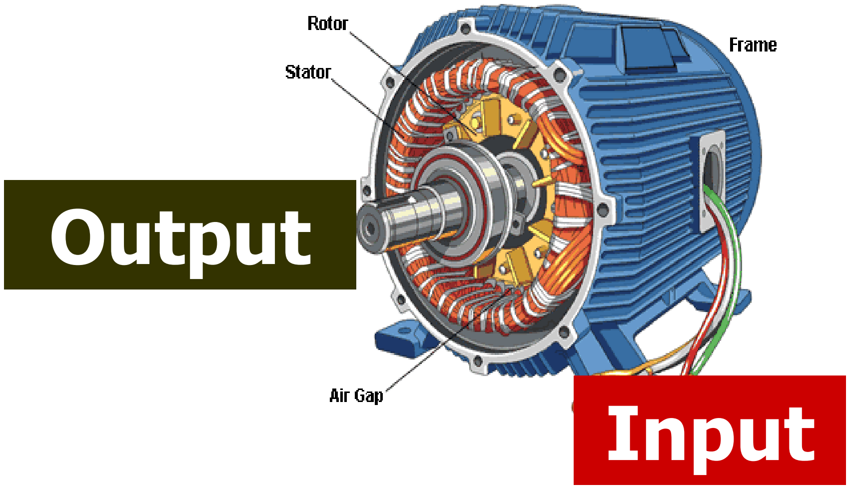
TYPES OF MOTORS

- **AC MOTORS**
  - **Very common in Industries**

- **DC Motors**
  - **Generally installed for variable speed applications**

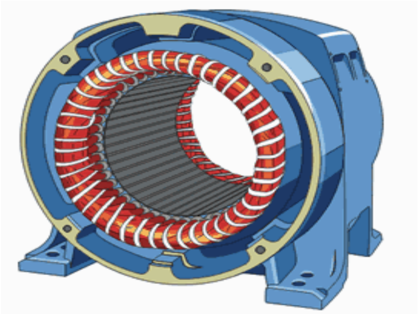
Motor Efficiency

Effectiveness with which a motor converts *Electrical* energy to *Mechanical* Energy



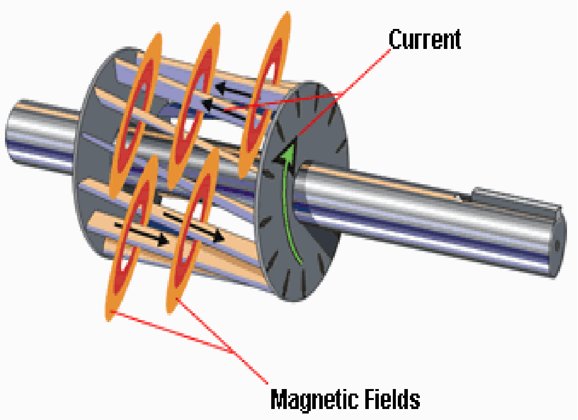
$$\text{Efficiency} = \frac{\text{Out put Power}}{\text{Input Power}} \times 100$$

AC Induction Motor



Primary winding connected to "POWER SOURCE"

STATOR



Secondary winding carries "INDUCED CURRENT"

ROTOR

Watts Losses

- Stator & Rotor losses - $I^2 R$
- Iron loss – Voltage Dependent
- Friction & windage losses - Independent
- Stray load loss – over hang, air gap etc

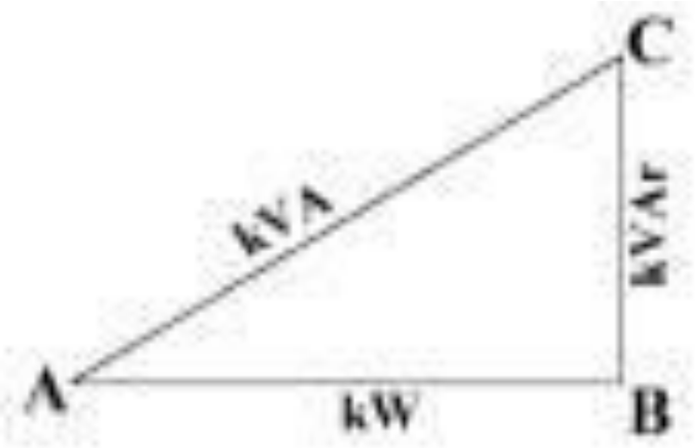
Motor Losses

- Current dependent - Copper losses
  - Stator
  - Rotor
- Voltage dependent - Iron losses
  - Magnetization
  - Eddy Current
- Friction and Windage losses

Range of Losses in AC Induction Motor

Range (H.P)	% of Loss	At FL Efficiency %
1 - 10	14 - 35	65 - 86
10 - 50	09 - 15	85 - 91
50 - 200	06 - 12	88 - 94
200 - 1500	04 - 07	93 - 96
1500 & above	4	95 - 96

Basic Formulas



Power=$\sqrt{3}$ V I Cos ϕ

Cos ϕ is power factor

Capacity α Torque

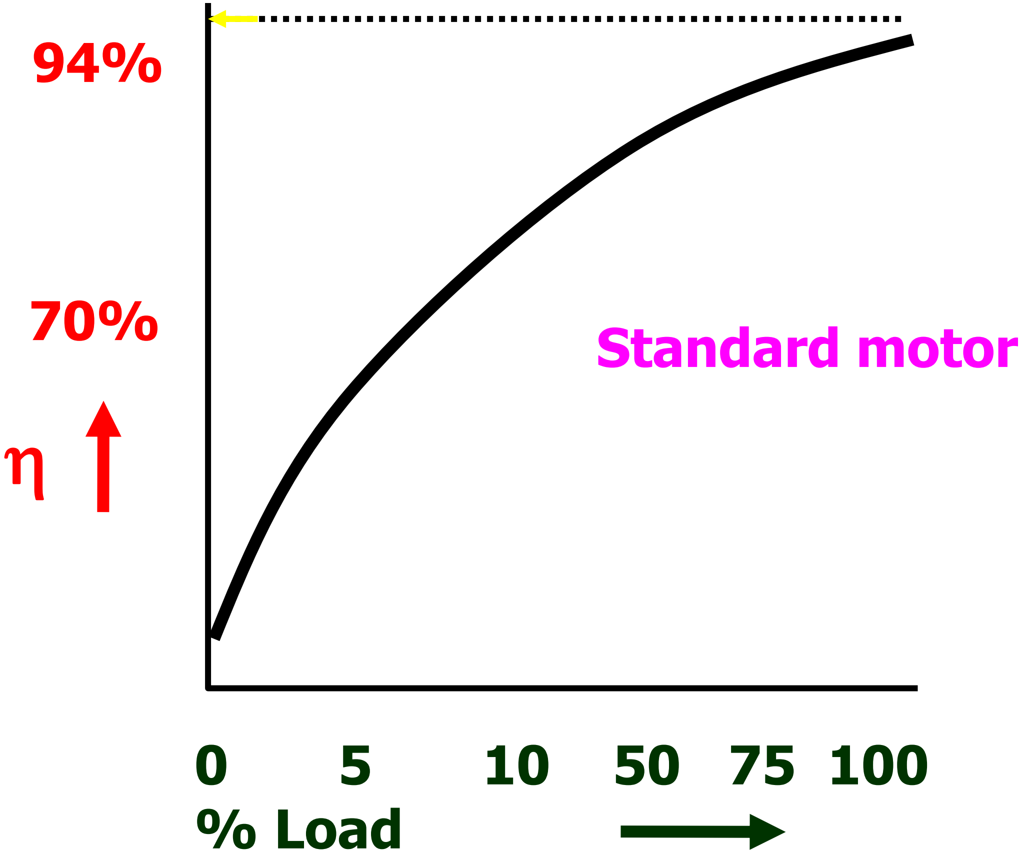
α Voltage^2

Energy Waste - Causes

- Use of less efficient motors
- Oversized /under loaded motors
- Improper supply voltage
- Voltage fluctuations
- Poor power factor
- Idle running

Motor Efficiency - Improvement

Capacity α Voltage ^{2}



Voltage Optimization

Capacity α Voltage ^{2}

Impact on motor operating parameters

- Capacity reduces
- Reduction in voltage dependent losses - Drop in Magnetization current
- PF improves
- Load current drops
- Load factor improves
- Efficiency Improves

Voltage Optimization

What are the effects of voltage optimization?

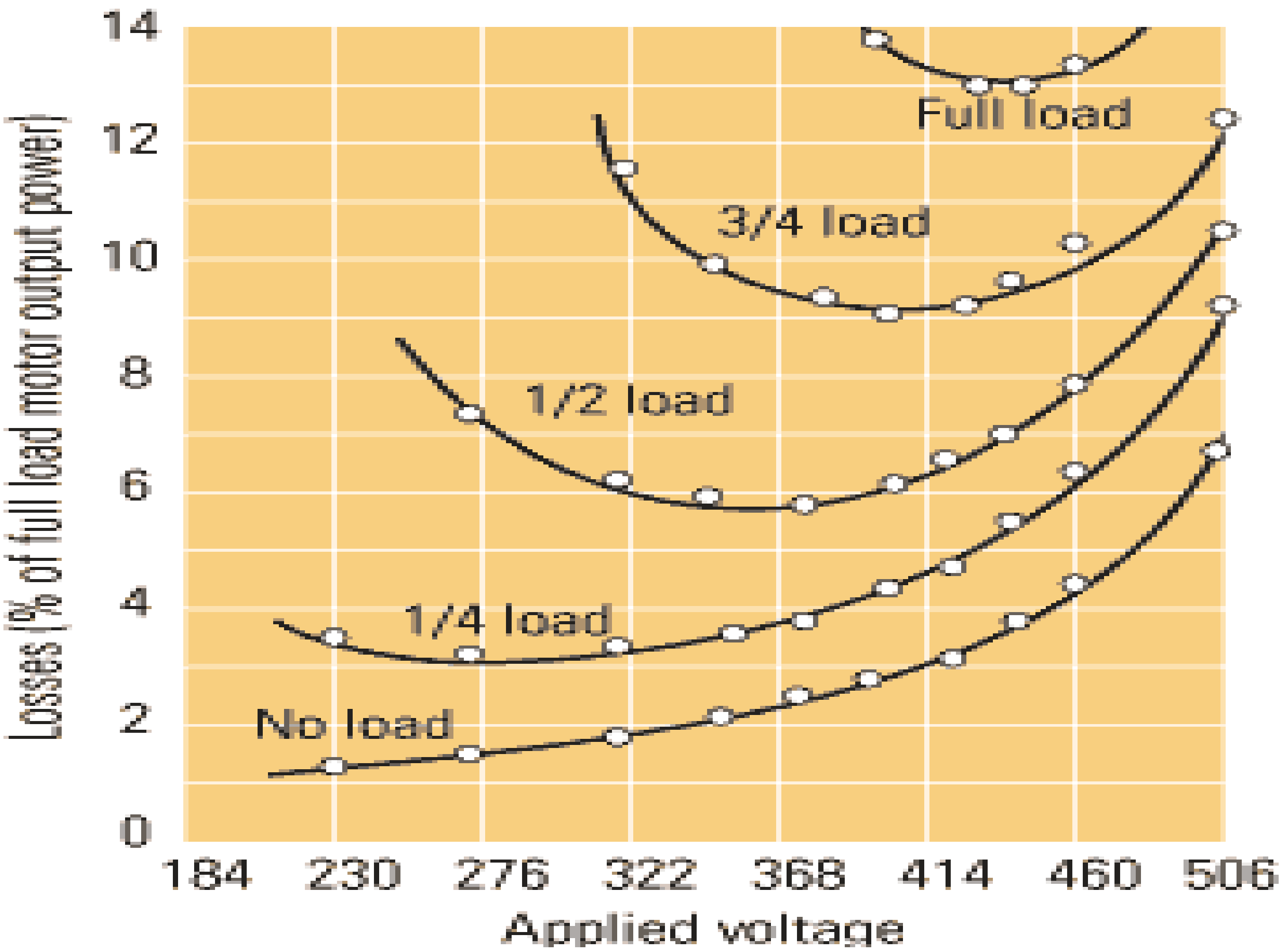
(Voltage 415 V --> 400 V)

- 100 HP Motor - 100 % Loading
  Increase in Load Current

- 100 HP Motor - 80% Loading
  Decrease in Load Current – Optimum Level

- 100 HP Motor - 50% Loading
  Decrease in load current – Still Potential

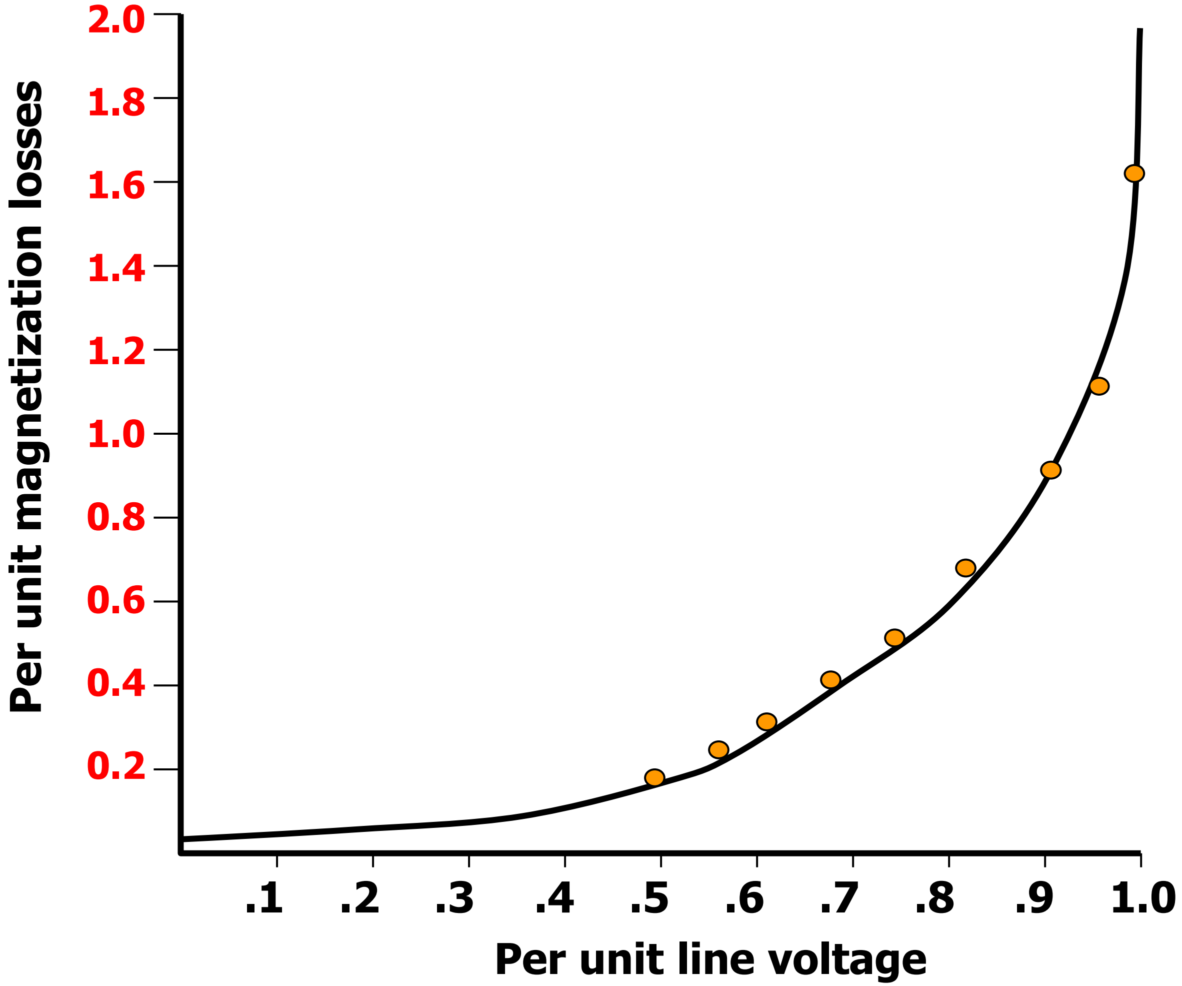
Effect of Voltage on Motor Losses



Optimize The Plant Operating Voltage - Overall

- Plant operating voltage plays a critical role in energy conservation
- On line voltage optimising devices to regulate the operating voltage
- Magnetization losses vary exponentially with the voltage

Motor Magnetization Losses Vs Motor Voltage



Optimise The Plant Operating Voltage-Overall

- **Voltage optimisation Potential will vary with over all Loading pattern of all motors**
- **To be implemented after analysing the loading pattern of all motors**
- **Reduce Voltage from rated value – *In steps***
- **Monitor Energy Consumption**
- **Arrive at Optimum Voltage**

Voltage Optimisation-Overall

- Distribution Transformers
- 2000 kVA, 433 Volts Supply Voltage
- LT Motors Loading : 20 – 80%
- Transformer tap position reduced from normal tap
- Voltage before optimization = 420 Volts
- Average Load = 850-900 KW
- Optimized voltage = 400-405 Volts

Annual Savings : Rs.1.3 Lakhs

Energy Efficient Motor

WHY MOTORS ARE BECOMING LESS EFFICIENT

1

- Over Sized / Under loaded Motors

2

- Improper Supply Voltage

3

- Use of Less Efficient Motors

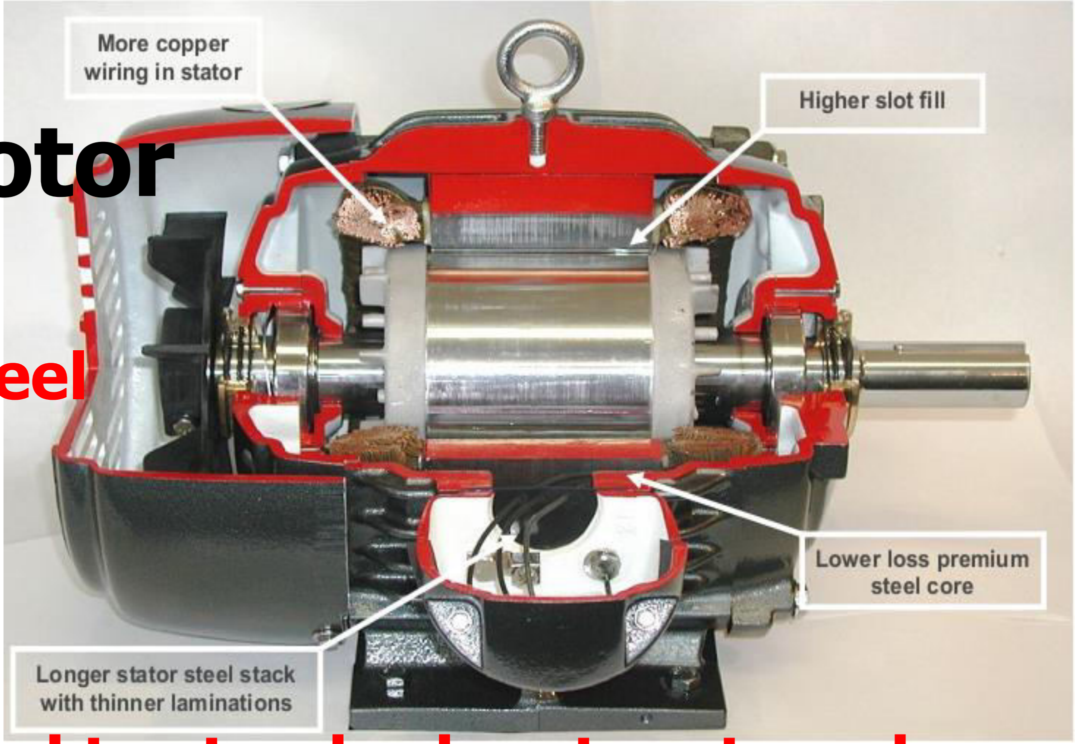
4

- Poor Power Factor

5

- Rewinding of Motors

Energy Efficient Motor



- Use of lower loss silicon steel
- Longer core
- Thicker wires
- Thinner laminations
- 20% more copper compared to standard motors to reduce the stator losses
- Rotor losses are reduced by increasing the mass of rotor conductors and / or increasing their conductivity
- Precision air gaps to reduce current requirements
- Improved winding and lamination designs to minimize energy consumption

Energy Efficient Motor

- lesser slip
- Improved fan design
  - Cooler operation & Increases motor insulation life
- 1.15 service factor
  - Greater flexibility in handling voltage variations and imbalances
- High power factor
  - Eliminate need for PF correction

Energy Efficient Motors

New efficiency classes defined by IEC

Super premium efficiency *	IE4	Super premium efficiency
Premium efficiency	IE3	Premium
High efficiency	IE2	Comparable to EFF1
Standard efficiency	IE1	Comparable to EFF2

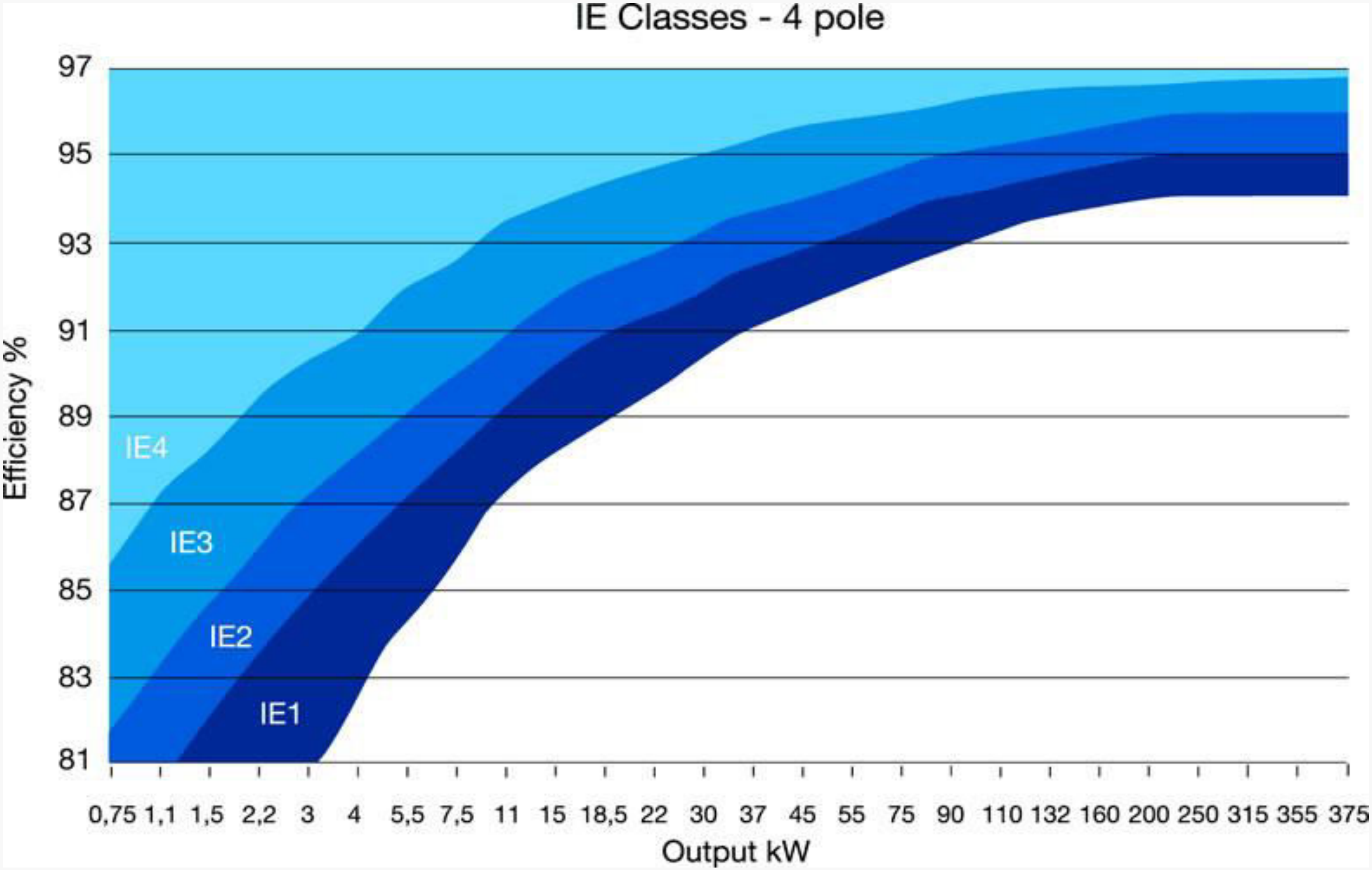
IEC standard indicated a Super Premium class with 15% lower losses than the IE3

Comparison of efficiencies of Standard & Energy Efficient Motors

Output 4 Pole	IS 8789	eff 2 as per IS 12615	eff 1 as per IS 12615
0.75 kW	71.0%	73.0%	82.5%
1.5 kW	76.0%	78.5%	85.0%
3.7 kW	83.0%	84.0%	88.3%
11 kW	85.5%	88.4%	91.0%
18.5kW	87.0%	90.0%	92.2%
37 kW	88.5%	92.0%	93.6%
75 kW	Not specified	93.6%	94.7%
110 kW	Not specified	94.4%	95.2%
160 kW	Not specified	95.0%	95.8%

Efficiency values are subject to tolerance as per IS325

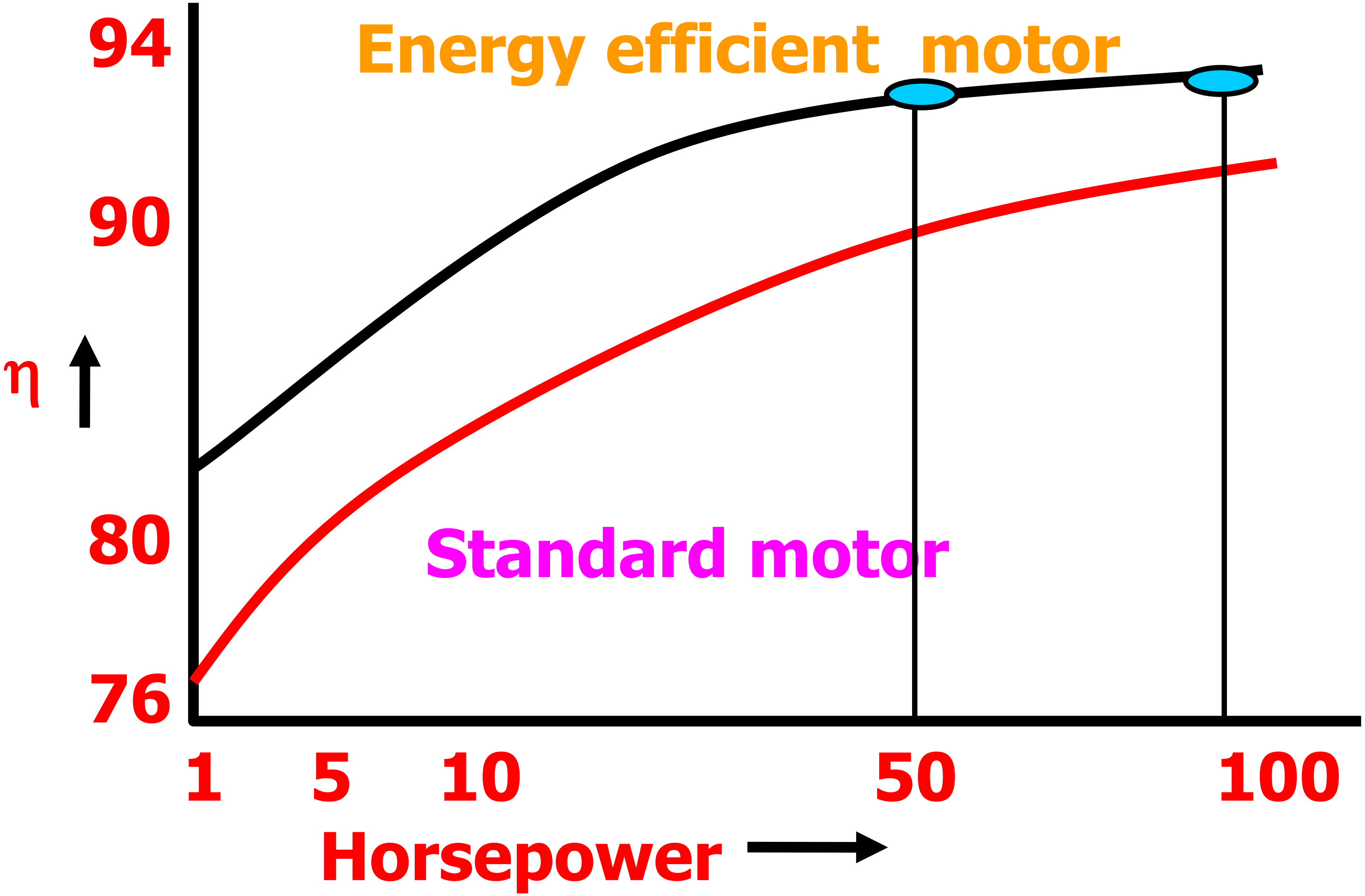
IE efficiency classes for 50 Hz 4-pole motors



Loading vs Efficiency

- **Motors are generally loaded between 40-60%**
  - **Due to Higher starting Torque**
  - **Varying process requirements**
- **Efficiency of Energy Efficient Motors is higher than conventional motors and flat between 50-100% loading**

Energy Efficient Motor – Part load Operation



Advantages

- Optimum efficiency
- Longer life
- Lower operating cost
- Better tolerance to thermal and electrical stresses
- Ability to operate at higher ambient temperature
- Can withstand abnormal operating conditions

When to Install EE Motors?

New Projects

- EE Motors ideally suited

Rewinding of Old motors

- In case of Normal Failure
- Fit case for Replacement after rewound 5 times

Applications where EE motors cannot be installed ?

EE Motors are not to be Installed for Intermittent duty applications like crane, Hoist etc

Rewound Motors

Motor Burning

- Quality of insulation between stampings detoriates
- Eddy current losses increases
- Magnetic property detoriates
  - ☐ Magnetic losses increases
- Causes drop in efficiency

Rewound Motors

Bearing failure

- Rotor scratches stator
- Air gap becomes uneven
- Torque induced not uniform
- Net torque developed is low
- Causes drop in efficiency
- Motors replacement should be analysed case to case basis
- Maximum 5 times motor can undergo rewinding – normal failure

Replace Conventional Old Motors With Energy Efficient Motors

- **It has been implemented in many industries**
- **Case study is from one of the textiles industry**
- **Ring frames are vital and continuous operating equipment in textile industry**
- **Total number of RF machines - 30 Nos.**

Replace Conventional Old Motors With Energy Efficient Motors

Continuous operation

Results:

Motors	Rated kW	No load kW	Load kW
Old motor	15.0	2.32	9.92
Energy efficient motor	15.0	1.56	7.36
Difference in consumption		0.76	2.56

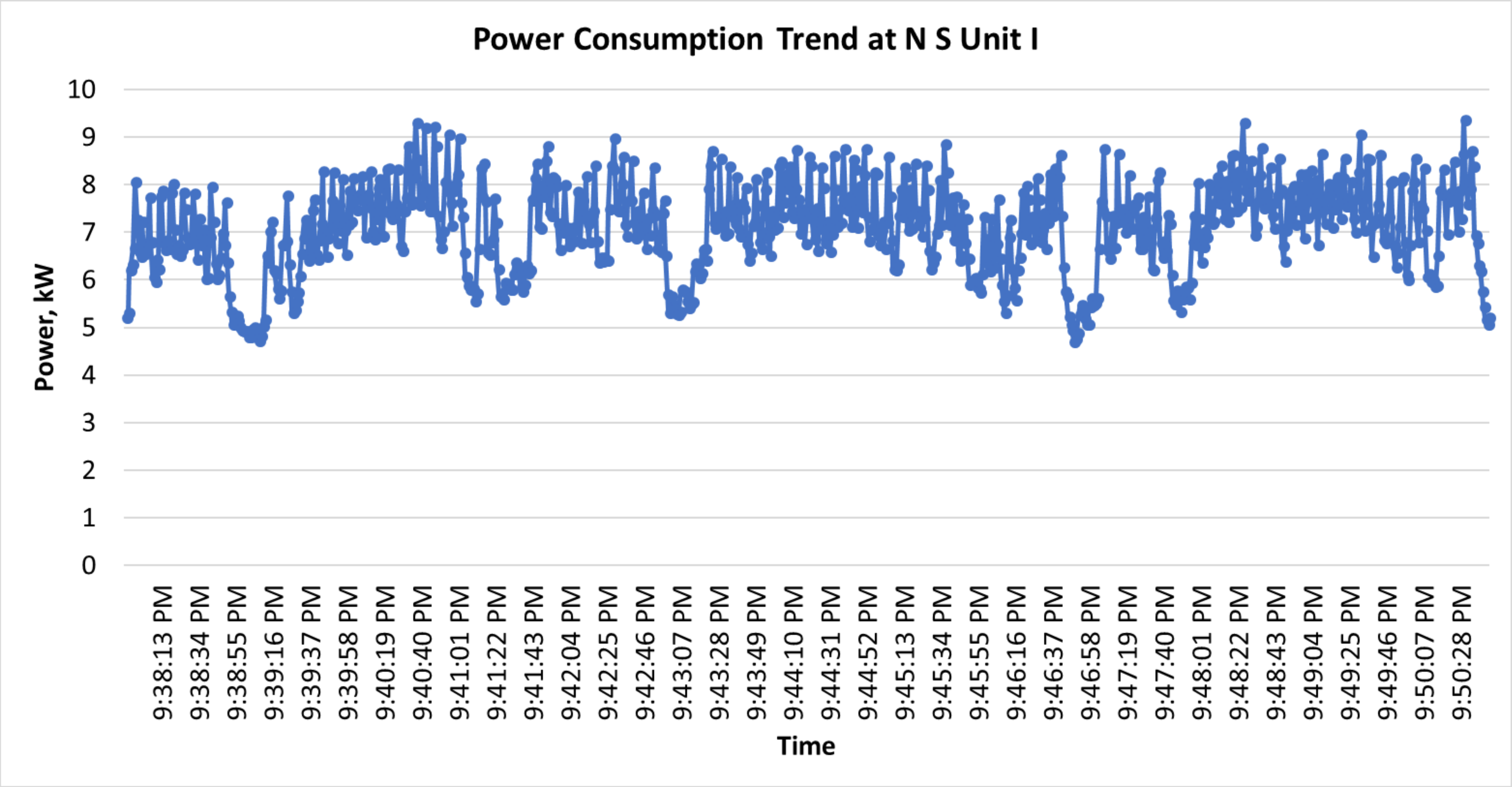
Savings : Rs. 6.7 lakhs
Investment : Rs.10.2 lakhs
Pay back : 19 month

Comparison with Energy Efficient Motor

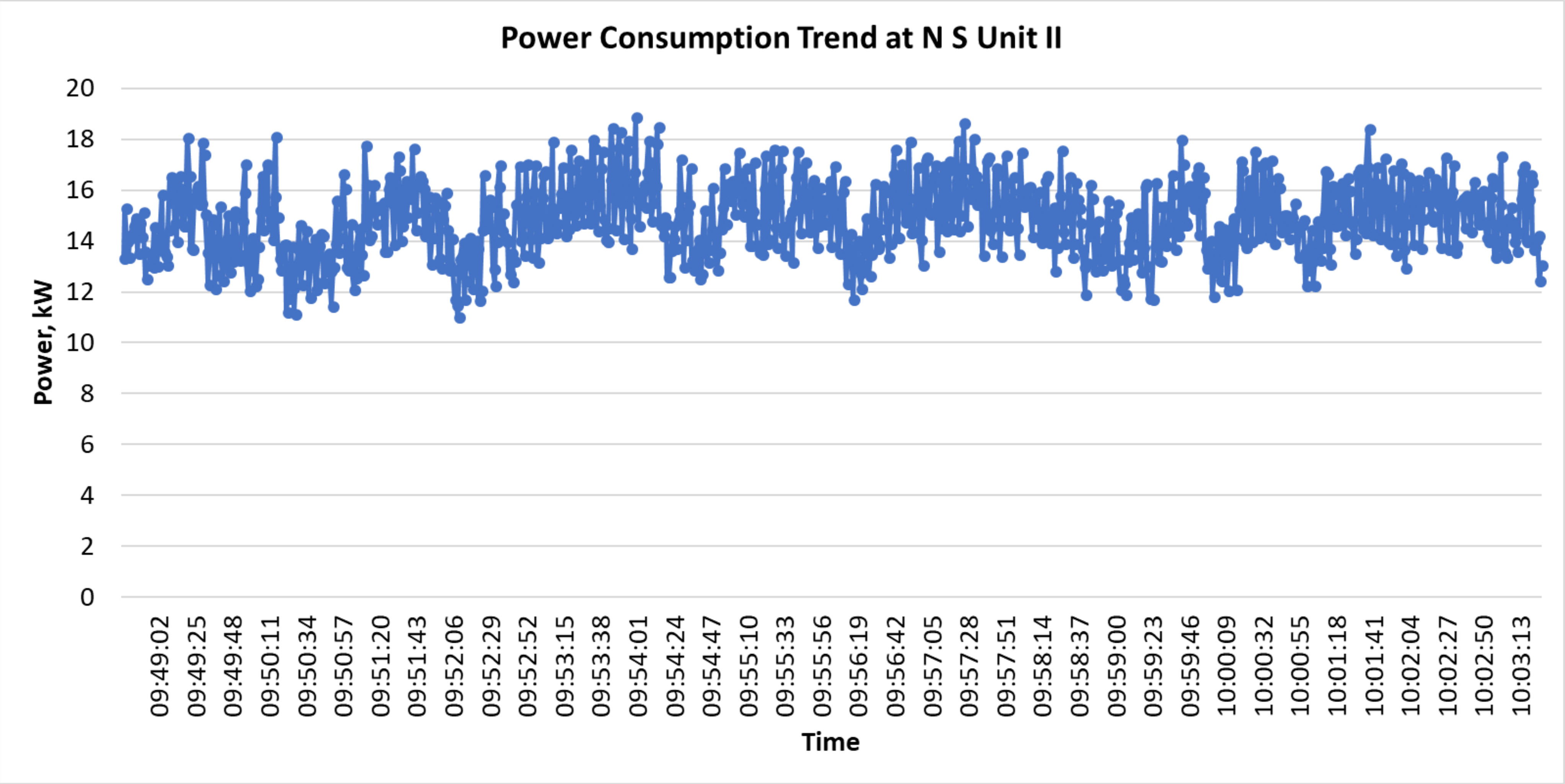
- There are two same size motor is operating for one part, punching Application
- Following table shows the details of Grinder Machine

Area	Rating of Motor	Running Power of Motor	
	HP	kW	
Punching-1	15	14.0	5 Times Rewind
Punching-2	15	7.0	New

Comparison with Energy Efficient Motor



Comparison with Energy Efficient Motor



Install New Energy Efficient Motor

Proposed System

- Install EE Motor
- Lower Power consumption
- More than 25% of energy saving at present power consumption

Install New Energy Efficient Motor

Saving = 14 kW x 25% x 6 hrs x 300 Days x Rs 7.50

Annual Savings	**: Rs. 0.47 Lakhs**
Investment	**: Rs. 1.48 Lakhs**
Payback	**: 38 Months**

Summary – EE Motors

- National standard IS 12615: 2004 for energy efficient three phase induction motors from 0.37kW to 160 kW
- Energy savings are more at partial loads because Energy Efficient motors have a Flat Efficiency Vs. Load Characteristic
- Payback period of eff2 motor over IS-8789 motor is approx. 1500 to 2000 working hrs.
- Payback period of eff1 motor over eff2 motor is approx. 2500 - 3000 working hrs.

Sum-up

Sizing of the motor is critical and important

- Oversizing will result in
  - ☐ More losses
  - ☐ Lower efficiency
- Under-sizing will result in
  - ☐ Overloading
  - ☐ Overheating & failures
- Optimal sizing will result in
  - ☐ Minimum losses
  - ☐ Maximum efficiency

Sum-up

- **History Card**
  - ☐ **Regular Updation**
- **Joint Ownership with the process team**
- **Energy Efficient Motor**
  - ☐ **Replacement – Rewound Motors**

Thank you

Furnaces

Furnaces Operating Costs

Present Analysis –

Unit I			
S N	**Parameters**	**Units**	**Figures**
1	Fo Consumption	Litres/Day	80
1	FO Cost	Rs./Kg	33
3	Plant Running hours	Hours/Day	6
4	Plant Running days	Days/Annum	300
5	Weight of Product	gm	250
6	Average Production	Pieces/Day	1500
7	Specific Energy Consumption	Liters/Ton	187

Furnaces Operating Costs

Present Analysis –

Unit II			
S N	**Parameters**	**Units**	**Figures**
1	Fo Consumption	Litres/Day	70
1	FO Cost	Rs./Kg	33
3	Plant Running hours	Hours/Day	6
4	Plant Running days	Days/Annum	300
5	Weight of Product	gm	250
6	Average Production	Pieces/Day	1500
7	Specific Energy Consumption	Liters/Ton	186

Furnaces Operating Costs

Present Analysis –

Unit III			
S N	**Parameters**	**Units**	**Figures**
1	Fo Consumption	Litres/Day	80
1	FO Cost	Rs./Kg	33
3	Plant Running hours	Hours/Day	6
4	Plant Running days	Days/Annum	300
5	Weight of Product	gm	290
6	Average Production	Pieces/Day	1700
7	Specific Energy Consumption	Liters/Ton	162
8	Specific Energy Consumption (Recommended)	Liters/Ton	72
9	Saving Potential	Rs./Year	5,00,000

Furnaces Operating Costs

Annual Savings - Rs. 5.00 Lakhs