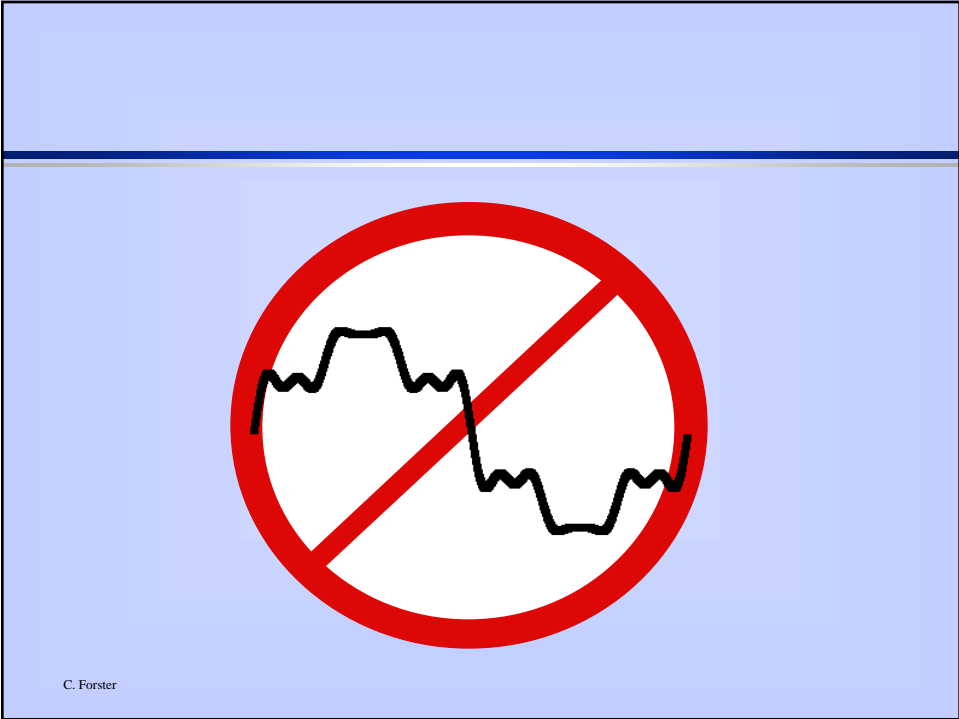



*Do You Have a Problem with IEEE-519?*

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???????

**Do You Have a  
Harmonic Problem?**

 **Forster Electrical Engineering, Inc.**  
550 N. Burr Oak Ave, Oregon, WI 53575 (608) 835-9009  
(608) 835-9039 fax

C. Forster

## What is THD?

**T**otal **H**armonic **D**istortion  
(DF - Distortion factor)

Ratio of RMS value of harm. to RMS  
value of 60 hz fundamental

C. Forster

## What is TDD?

**T**otal **D**emand **D**istortion -  
The harmonic current distortion  
expressed as a % of *the maximum*  
*DEMAND* load current using a  
15 or 30 minute demand period

C. Forster

## What is PCC?

### **P**oint of **C**ommon **C**onnection

Between Utility/Customer - Usually the metering or incoming service point

For the Customer/Equipment Supplier:

Usually the point in the plant where the equipment is connected

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### Chuck's Golden Rule of Harmonics

**Thou shalt not draw so much distorted current that you upset the voltage waveform**

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## How to prevent breaking this rule

- \* Make the source “stiffer”
- \* Draw less distorted current
- \* Reduce the distortion in the current drawn

## How much Distortion is OK?

- \* Are you a Utility?
- \* Are you a Customer?

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If you are a Utility...

You must provide a  
**VOLTAGE** at the  
**PCC** that has distortion  
less than **5% THD**

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...usually

If you are a Customer...

You must limit your  
**CURRENT** distortion at  
the **PCC** to less than  
**5% THD**.....usually

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**The goal of limiting  
CURRENT distortion  
from the Customer is..**

**To prevent distortion of  
the VOLTAGE  
waveform**

**The goal is to limit the  
maximum individual  
VOLTAGE harmonic to  
3% and the THD to 5%**

## Let's look at a real Customer...

- ♥ This is a 12.47 kV **foundry** customer in Wisconsin.
- ♥ The Customer **peak demand** is 5,000 kW and 5,882 kVA
- ♥ The Utility **Supply** is 12.47 kV

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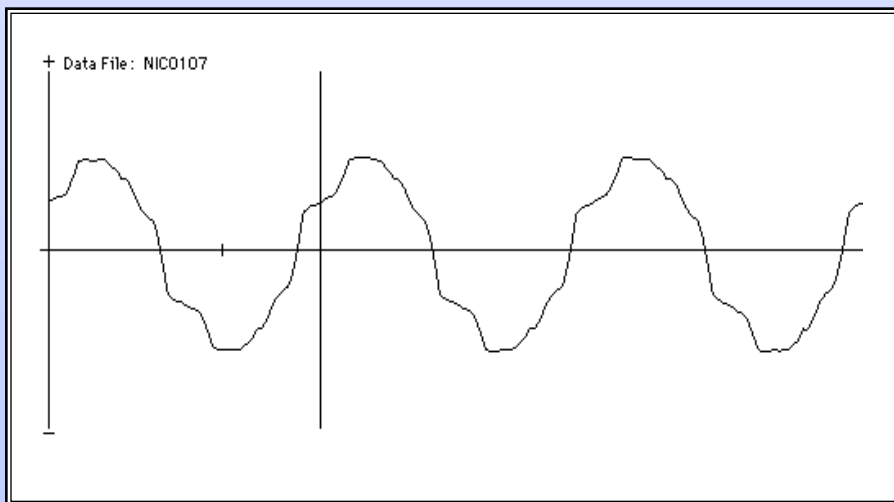
## Can the customer meet IEEE-519 “CURRENT” requirements?

Assume the substation supplying the load has had **PEAK** loads over the last **12 months** equal to the **kVA rating** of the transformer.

## **What to do first?**

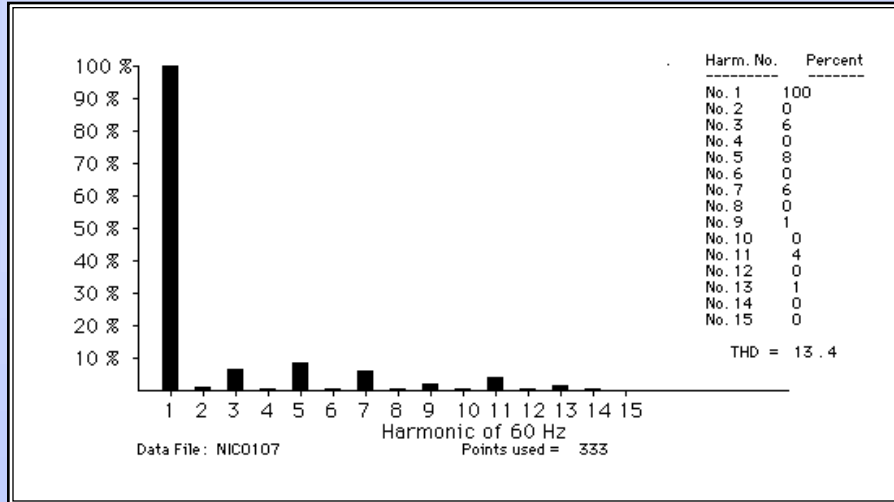
**Make field  
measurements of  
current waveforms at  
the PCC**

## **Current waveform with 3,500 kVA load**





## Frequency spectrum for the above 12.47 kV CURRENT



Assuming the average  
peak monthly demand  
was 5,000 kW, what is  
the **TDD**?

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## Some information first..

System Incoming kV **12.47** kV  
Peak Monthly kWD **5,000** (Avg Pk/yr)  
P.F. at Peak **0.85** (0 to 1.0)  
Peak Monthly kVAD **5,882** kVAD

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## More information..

$I_L$  (Load Amperes) **272** (Avg Pk/yr)  
Isc(Short Ckt Amps) **5,500** Amperes  
 $I_{sc} / I_L$  **20** ratio  
System load @ test **162** Amperes RMS

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## Using the data above..

Harm. No.	Meas. Harm. %	Load Harm. Amps	% of Peak Dem.(I <sub>L</sub> )
3	6.59	10.68 <small>(162 x 0.0659)</small>	3.92
5	8.53	13.82	5.07
7	6.23	10.09	3.71
9	1.96	3.18	1.17
11	4.1	6.64	2.44
13	1.37	2.22	0.81 <small>(2.22 / 275 x 100%)</small>

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## Using the data above..

Harm. No.	Meas. Harm. %	Load Harm. Amps	% of Peak Dem.(I <sub>L</sub> )
15	0.083	0.13	0.05
17	0.69	1.12	0.41
19	0.52	0.84	0.31
21	0.22	0.36	0.13
23	0.385	0.62	0.23

**Measured THD (%) 13.36%**

**Total Demand Distortion (%) 7.95%**

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## How to calculate TDD...

Harmonic number and measured **harmonic values** are from the measurement device output.

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## How to calculate TDD...

Load harmonic amperes =  
Measured harmonics% times load in  
amperes at the time of the test  
 $(162 \times 0.0659) = 10.68$  Amps

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## How to calculate TDD...

% of Peak Demand = Load harmonic  
amperes divided by peak monthly  
ampere demand, expressed as %  
 $(2.22 / 275 \times 100\%) = 0.81\%$

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## How to calculate THD...

Measured **THD** is the sq.  
rt. of the sum of the squares  
of each Measured  
Harmonic in %

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## How to calculate **TDD**...

**Total Demand Distortion** equals the square root of the sum of the squares of each **Peak Demand** value in %

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**Did the Foundry meet IEEE-519 “CURRENT” requirements?**

**Yes** - The maximum TDD allowed is 8.00%. This is acceptable

**WAIT!** - someone just  
said 5% was the  
**CURRENT** limit!

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Check Table 10.3 in IEEE-519

**Maximum Harm. Current Distortion in % of  $I_L$**

Limits for individual harmonic order ( Odd Harmonics)

$I_{SC} / I_L$	<11	11<h<17	TDD
<20	4.0%	2.0%	5%
<b>20&lt;50</b>	<b>7.0%</b>	<b>3.5%</b>	<b>8%</b>
50<100	10.0%	4.5%	12.0%

**This is a partial copy of Table 10.3**

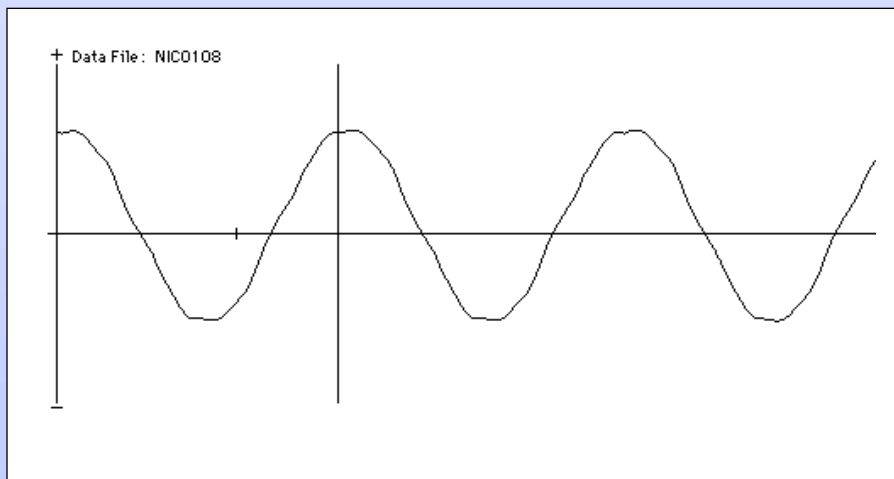
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???????

Did the Foundry load  
cause the UTILITY to  
exceed IEEE-519  
limits?

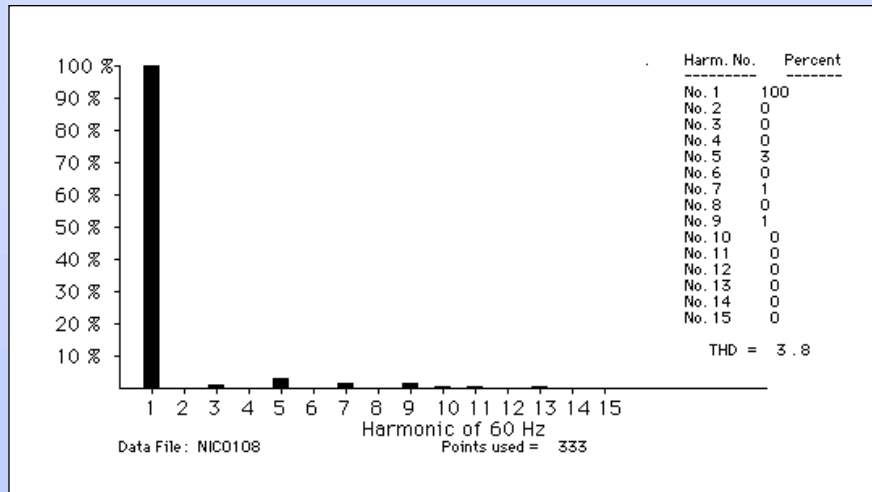
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How did the Foundry incoming  
12.47 kV **VOLTAGE** look?





Frequency spectrum for the above  
12.47 kV **VOLTAGE**



Did the **UTILITY** meet  
**VOLTAGE** distortion limits?

**Yes** - The THD limit was 5%  
with 3.8% measured.

The 5th harmonic was 3%, the  
limit was 3%.

## IEEE-519 Table 11.1- Voltage Limits

Bus Voltage at PCC	Indiv. Voltage Dist. (%)	Total Voltage THD (%)
-----	-----	-----
<b>69 kV and below</b>	<b>3%</b>	<b>5%</b>
69 kV to 161 kV	1.5%	2.5%
161 kV and above	1%	1.5%

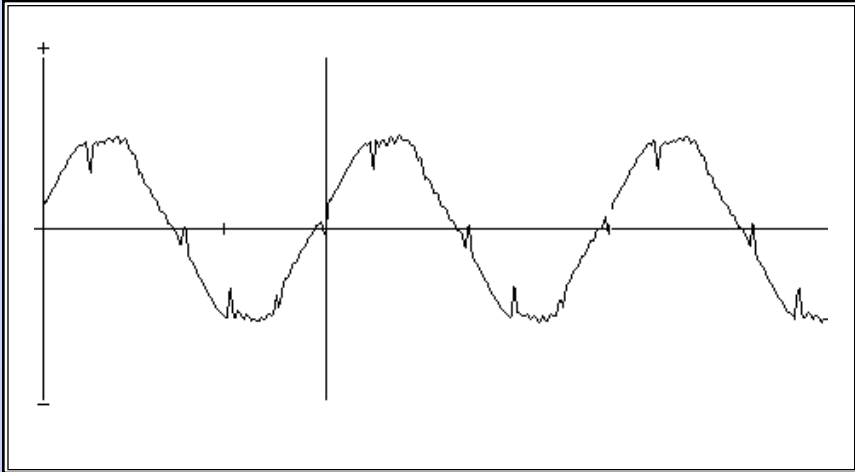
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## Another Topic...

### *Line Notching*

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750 kVA Induction Furnace - 480 volt  
**VOLTAGE** waveform at input to furnace



**End**

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