7.3. Insulating Fluids Subcommittee (R.K. Ladroga, Chair; S.J. McNelly, Vice-Chair)

7.3.1. Introduction/Attendance

The Insulating Fluids Subcommittee met in Minneapolis, Minnesota on Wednesday, October 17, 2007 with 26 members and 44 guests present. The following 8 guests requested membership:

Alfonso Nelson	Ibrahim Shteyh
Kent Brown	Don Platts
Jim Dukarm	Shuzhen Xu
Josh Herz	

Meeting Agenda

1. Introductions
2. Patents
3. Minutes Approval
4. WG Reports
5. New Business
6. Old Business
7. Adjourn

Introductions were made.

7.3.2. Approval of Meeting Minutes and Patent Disclosure

As required in IEEE SA Standard Boards by-law, Section 6.3.2, the IEEE patent disclosure requirements were discussed and a request was made for disclosure of any patents that may be related to the work of the WG. No new disclosures were forthcoming.

The Minutes of the Dallas, Texas meeting were approved as written.

7.3.3. Current Subcommittee Business

7.3.3.1. C57.104 – IEEE Guide for the Interpretation of Gases Generated in Oil – Immersed Transformers

Tuesday, October 16, 2007
Minneapolis, Minnesota

The meeting was called to order by Rick Ladroga at 1:50 pm on Tuesday, March 13, 2007. Vice Chair William Bartley and Secretary Susan McNelly were also in attendance. There were 30 members, 64 guests, and 10 guests requesting membership.

Guests requesting membership were:

Claude Beauchemin	Dharam Vir
Michel Duval	Herman Vogel
Kent Haggerty	Shuzhen Xu
David Hanson	
Tamyres Machado Junior	
Prem Patni	

Approval of minutes from the Spring 2007 meeting in Dallas, Texas was requested. The minutes were approved as written.

The IEEE Patent disclosure requirements were discussed and a request was made for disclosure of any patents that may be related to the work of the WG. There were no responses to the request for disclosure.

Introductions of attendees were made.

Update on status of recent ballot on C57.104:

The ballot has closed with 115 affirmative votes, 3 negative votes, and 2 abstention votes. There were 120 votes received for 83% returned and 2% abstention.

A recirculation ballot committee will need to be formed to deal with resolution of the ballot comments. Rick Ladroga, Tom Prevost, Susan McNelly, Claude Beauchemin, and Luiz Chiem will be on the comment resolution committee.

Discussions for New Guide:

A new PAR request will be filed to start over with an immediate revision to the guide to address the remaining issues that have been raised as soon as the ballot process with the existing document is complete.

Status reports from Task Forces:

1. **Framework:**

   Jim Dukarm - Chair
   Tim Raymond
   Dave Hanson
   Jim Graham

   Presentation by Jim Dukarm – "A revised framework for the transformer DGA Guide.

   Design Goals:
   - Clear concise tutorial covering the essentials
   - Technical details included in an appendix or referred to external publications
   - Appropriate new features with discussion of appropriate grafics and case history examples
   - Provide enough practical information for someone to use the guide, but avoid "table of sacred numbers" if possible.

   Document Structure:
   - Introductory text
   - Scope, limitations, definitionc, etc.
   - Nature, purpose, and application of DGA
     - Nature - brief overview of entire process
     - Purpose – To improve safety and reliability while reducing cost.
     - Application – Risk management, detection and diagnosis of abnormalities, measurement verification and QA, DGA contexts (initial, screening, surveillance, monitoring, verification and QA).
   - DGA Norms
     - Characturistics of DGA data
     - Periodic variation
     - Skewed distributions
     - Measurement uncertainty
     - Derivation, use, and maintenance of norms. It is important to understand the DGA norms are neither purely statistical in nature nor universally applicable.

    - Variables and limit values
        - Minimum limits for gas concentrations
        - Combustible gas increments – baselines and limits
        - Combustible gas rates of increase – window and limits
        - CO2/CO
        - Acetylene/Hydrogen
        - Oxygen/Nitrogen
- DGA Data Interpretation
    - Data quality check before interpretation – List of most common problems
    - Initial assessment – First or isolated sample
    - Screening – Look for signs of suspicious change and classify acc to risk
    - Surveillance – Evaluate rates of change, get diagnosis, watch for danger
    - Monitoring
    - Measurement QA or verification
    - Use of graphics
- Addenda
    - Case histories – normal operation, faults, stray gassing, etc.
    - Graphical representations – types of charts and suggested uses
    - Diagnostic methods – Duval triangle, Rogers/IEC ratio
    - DGA calculations with measurement uncertainty – increments, average rates, ratios
    - Physical properties of gases – solubility, partial pressure, adsorption

Question – Is there a size transformer (volume of oil) that this guide will apply to. Response – For small pole top type units, the cost to do the analysis is not necessarily appropriate. The information itself is valid for all size units regardless of oil volume. For a small tank, there are less Joules of energy than for a large tank which evens things out. The guide needs to address this with documentation showing that this is true.

2. Data:

Tom Prevost – Chair	Claude Beauchemin
Dave Hanson	Jim Dukarm
Paul Boman	Dave Wallach
Paul Mushill	Jim Graham
Bob Ganser Jr	Joe Kelly

Tom reported that work is in progress and presented the input fields that we will be looking for when collecting the required data.

Manufacturer
S/N
Maximum *or Base* MVA
HV rating
LV rating
TV rating
Manufactured Year (*4 digit year*)
Transformer type (core form or shell form)
Preservation System Type (Gas blanketed, conservator, etc.)
Cooling Type (ONAN, ONAF, etc.)
LTC, Degree C Rise (55 or 65C)
Transformer Use (GSU, Transmission, Distribution, other)
Insulating Liquid (Fluid type)
Liquid volume (units)
Sample Date
Reason for sampling (routine, failure, other)
Repaired, Degassed, or Date of last reprocessing

Location (LTC, Bushing, Main Tank)
comment section
Inhibitor Content
Gases: H, O, N, Methane, CO, Ethane, CO2, Ethylene, Acetylene
comment section
Loading level

Items underlined in italics were additions made during discussion. Some of these items may be more appropriate as a list of items that should be tracked on units, but may be difficult to obtain from historical databases.

3. Case Studies:

Brian Sparling –Chair	Jim Graham
Kent Haggerty	Paul Boman
Dave Wallach	Bob Ganser Jr.
Dave Hanson	Paul Mushill
Tim Raymond	Joe Kelly
Norman Field	

No report at this time.

4. Diagnostic Methods

Tim Raymond – Chair	Lance Lewand
Michel Duval	Joe Kelly
Jerry Corkran	Norman Field

Michel Duval made a presentation on the proposed changes to the guide.

Other Business:

Bill Bartley will be moving on in his new roll as Standards SC Chair. Rick Ladroga nominated Susan McNelly to replace Bill as Vice Chair. A motion was made and passed.

The meeting was adjourned at 3:10 pm.

Rick Ladroga
WG Chair

Susan McNelly
WG Vice Chair and Secretary

7.3.3.2. C57.106 – IEEE Guide for Acceptance and Maintenance of Insulating Oil in Equipment

Tuesday, October 16, 2007
Minneapolis, Minnesota

The revision for the IEEE "Guide For Acceptance and Maintenance of Insulating Oil in Equipment," C57.106 –2006, was completed by Jim Thompson, Working Group Chair, and TV Oommen, Co-Chair. It was published on June 6, 2007 and made available in hard copy as of July 3, 2007.

October 17, 2007
James A. Thompson

7.3.3.3. C57.121 –IEEE Guide for Acceptance and Maintenance of Less Flammable HydroCarbon Fluid in Transformers

There was no WG meeting for this Guide at the Minneapolis, Minnesota meeting. This standard will be allowed to expire.

7.3.3.4. C57.130 - IEEE Trial-Use Guide for Dissolved Gas Analysis During Factory Temperature Rise Tests for the Evaluation of Oil-Immersed Transformers and Reactors

There was no WG meeting for this Guide at the Minneapolis, Minnesota meeting. A request for a one year extension for this Guide was filed Monday, October, 15, 2007. Tom Prevost would like to form a ballot resolution committee to resolve the outstanding ballot comments. Kent Haggerty, Dave Wallach, Juan Castellanos, Rick Ladroga, and Tom Prevost have volunteered to serve on the ballot resolution committee.

7.3.3.5. C57.139 - Draft IEEE Guide for Dissolved Gas Analysis Of Load Tap Changers

Tuesday, October 16, 2007
Minneapolis, Minnesota

Fredi Jakob called the WG meeting to order at 11:00 am, Tuesday, October 16, 2007. WG Secretary Susan McNelly was also present. There were 30 members and 28 guests present with 3 guests requesting membership.

Guests requesting membership were:

Michel Duval
Don Anderegg
Luiz Cheim

Agenda:

1. Welcome and Introduction
2. Patent considerations
3. Approval of Spring 2007 minutes
4. Status of the Guide
5. Joint Presentation by Dr. James Dukarm and Ms. Shuzhen Xu
6. What next?
7. Adjourn

The IEEE Patent disclosure requirements were discussed and a request was made for disclosure of any patents that may be related to the work of the WG. There were no responses to the request for disclosure.

Approval of minutes from the Fall 2006 meeting in Dallas, Texas was requested. The minutes were approved as written.

A draft of the Guide is expected to be ready for discussion prior to and at the Spring 2008 meeting in Charlotte, NC. We are currently working on a tight time schedule due to the fact that our work has been extended for only a short period. In order to get the draft ready for the next meeting, members who can join our subgroup and contribute to the development of the draft were requested to come forward.

Jim Dukarm and Shuzhen Xu have made significant progress in their statistical studies and jointly presented their results. The presentation is attached.

Several people also volunteered to review the draft document prior to the Spring 2008 meeting.

The meeting was adjourned at 12:20 pm.

Fredi Jakob
Chair

Susan McNelly
Secretary

7.3.3.6. C57.147 - IEEE Guide for Acceptance and Maintenance of Natural Ester Fluids in Transformers

Tuesday, October 16, 2007
Minneapolis, Minnesota

The WG meeting was called to order at 8:05 am, on Tuesday, October 16, 2007 by the working group Chair, Patrick McShane. Vice Chair, Clair Claiborne, and Secretary, Susan McNelly were also present. There were 13 members present and 44 guests, with 5 guests requesting membership. Since the Guide has been balloted, no additional membership requests will be entertained.

Meeting Agenda

1. Introductions
2. Patents
3. Minutes
4. Update
5. Review last revisions
6. Vote to Submit for Balloting (Recirculation)
7. New Business
8. Adjourn

As required in IEEE SA Standard Boards by-law, Section 6.3.2, the IEEE patent disclosure requirements were discussed and a request was made for disclosure of any patents that may be related to the work of the WG. No new disclosures were forthcoming.

The minutes for the Spring 2007 meeting were approved as submitted and recorded on the website.

Update:

Since the last meeting, the standard went to Ballot and the results are now available. The requirement for >75% balloting was met. The ballot had 98.8% approval, with one negative (34 comments). Matt Ceglia, from IEEE, addressed the reason why a recirculation ballot is required. When a negative ballot with comments is received, a recirculation is required. For the subsequent round(s) of balloting new negatives (comments received on sections previously commented or sections that the working group modified prior to the recirculation) could also cause additional recirculations. Comments from subsequent rounds of balloting that are not tied to sections previously open for comment, do not require mitigation.

The PAR for this standard will expire at the end of the year. An extension has been filed and will be reviewed for approval by REVCOM. A PAR extension has been requested due to the recirculation ballot that will be required.

Formation of two task forces involving natural ester based dielectric coolants were discussed at the last meeting and approved at the Fluid Subcommittee meeting.

1. TF on DGA for Natural Esters – Paul Bowman has agreed to chair this TF

2. TF for Guide for Retrofill of Natural Ester Fluids – Jim Graham has agreed to chair this TF

Key ballot comments were reviewed for the remainder of the meeting.

ASTM References – Eliminated D 3613 as this standard has been recently withdrawn. Several other ASTM standards were also added.

Several minor grammatical or spelling corrections were made

A revised draft with ballot comments incorporated, as appropriate, and a listing of the ballot comments and responses to these comments will be submitted for recirculation ballot as soon as possible.

The Chair thanked all the WG and other participants contributing to this proposed guide.

A comment was made that IEC has recently formed a working group for a Natural Ester Fluid.

The meeting was adjourned at 9:15am.

Respectfully Submitted

Patrick McShane
Working Group Chair

Clair Claiborne
Working Group Vice-Chair

Susan McNelly
Working Group Secretary

7.3.3.7. Furan TF

Monday, October 15, 2007
Minneapolis, Minnesota

The working team or subteam of the Furan Task Force met at 3PM on Wednesday, October 17, 2007. Team members Luiz Cheim, Kent Haggerty, Don Platts, Tom Prevost, and Shuzhen Xu participated.

After discussing the path forward options, the team agreed that the next steps should be as follows:

1. Develop a white paper (approximately 8 pages) incorporating the major issues and current knowledge on Furans. Paper should include the following sections:
   - Scope or Purpose
   - History of Furans
   - How Furans are formed in oil
   - Current ongoing work and studies by various companies and organizations including CIGRE, testing companies, utilities, and users globally.
   - Correlation of DP and Furan data from known databases and studies. Connect insulation age with Furans. Also compare 55 to 65 degree rise transformers. Correlation should include both non-thermally and thermally upgraded paper. Include guidance in paper on where paper samples should be taken from transformer winding when measuring DP.

- Use of Furans for diagnostics and known limitations such as partitioning of oil, factors that can affect readings and values, types of transformers and applications, loading, oil quality, etc. (How do you move from Laboratory values to real life?)
- Key learnings from previous studies by CIGRE
- Technical position, additional data gathering, and objective of data analysis.
- Conclusions

2. Concurrent with development of a white paper, continue to gather Furan data as part of the data survey for DGA.

3. Set up process to more effectively obtain DP measurement data from failed transformers. Again, provide guidance on where in transformer to gather samples.

4. Expand Task Force membership to include utilities and testing companies.

Tom Prevost agreed to contact Randy Stebbins of SD Myers for information and technical data from his technical paper. Don Platts will contact additional utilities.

Shuzhen Xu and Luiz Cheim agreed to develop a draft of the paper for review by December. Goal would be to have a draft of the white paper ready for review by the task force by the next meeting in Charlotte, NC.

Respectfully Submitted,

Kent Haggerty, TF Chair

7.3.4. Old Business

C57.130 – IEEE Trial-Use Guide for the Use of Dissolved Gas Analysis During Factory Temeprature Rise Tests for the Evaluation of Oil-Immersed Transformers and Reactors - The PAR expires at the end of this year. Tom Prevost and Rick Ladroga will work together to will try and obtain the ballot resolution information and to determine what is required to move forward with this Guide.

Patrick McShane announced that a new task force concerning DGA for Natural Ester Fluids has been formed. Paul Bowman has volunteered to chair this task force.

Patrick McShane announced that a new task force concerning the application Guide for the use of Natural Ester Fluids (installation, filling, hold times, cold start, etc.) has been formed. Jim Graham has volunteered to chair this task force.

Jim Thompson brought up that the IEEE Std 637 – IEEE Guide for the Reclamation of Insulating Oil and Criteria for its Use has been reaffirmed. Tom Prevost recommended that the next time this guide is revised, that consideration be given to give it a C57 designation so that is falls under the umbrella of the transformer standards numbering.

7.3.5. New Business

Due to Bill Bartley moving on to a new role as Chair of the Standards Committee, Susan McNelly will step up to fill his vacated Fluids SC Chair position.

The reaffirmation for the IEEE “Guide For Reclamation of Insulating Oil and Criteria For Its Use,” Std 637 – 1985, was completed by Jim Thompson, Working Group Chair in August of 2007. The initial ballot and re-circulation ballot resulted in an 86 % response rate and a 95 % approval rate. RevCom approved the document reaffirmation on September 26, 2007.

It was announced that a Study Group would be formed regarding the revision of the IEEE Std 637 – 1985 Guide. Jim Thompson volunteered to chair a future working group and three people volunteered to help. Tom Prevost suggested a revised document name to include a C57 number rather than an IEEE Standard number to provide a more uniform reference for the document.

Ray Bartnikas reported that an IEC TC-10 meeting on insulating fluids will be held next week. They are still quite concerned with corrosive sulfur, which has been more problematic in Europe. Bipin Patel asked if there were any surveys concerning the corrosive sulfur issue. Ray indicated only that there had been a considerable number of failures in Brazil and Italy, but no definitive results were available. Rick Ladroga indicated that Doble had provided a tutorial on the corrosive sulfur issues a couple of years ago. Luiz Cheim indicated that there is a new test available that will be proposed by the IEC task force. This new test can better detect the presence of the corrosive sulfur. This new test method is comparable to the ASTM 1275, method B test.

Ray also indicated that there has been considerable interest in IEC to develop a standard for Natural Ester Fluids.

7.3.6. Adjournment

The Subcommittee adjourned at 12:12 pm.

Next Meeting:

> The Insulating Fluids Subcommittee and its Working Groups will next meet in Charlotte, North Carolina during the period of March 16 – 20, 2007.

Respectfully Submitted

Richard Ladroga
Fluids SC Chair

Susan McNelly
Fluids SC Vice-Chair

Statistical Derivation of LTC Gas Ratio Norms

Jim Dukarm and Shuzhen Xu

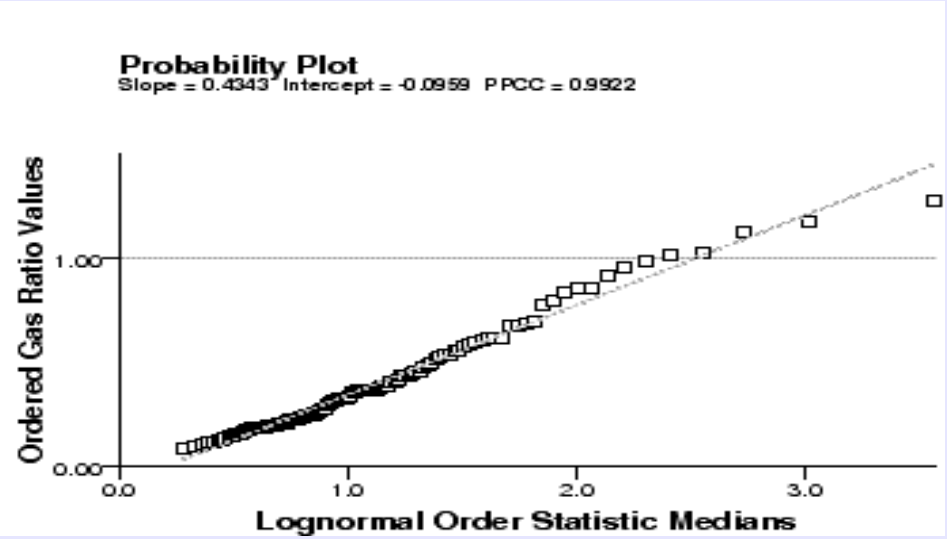
Overview

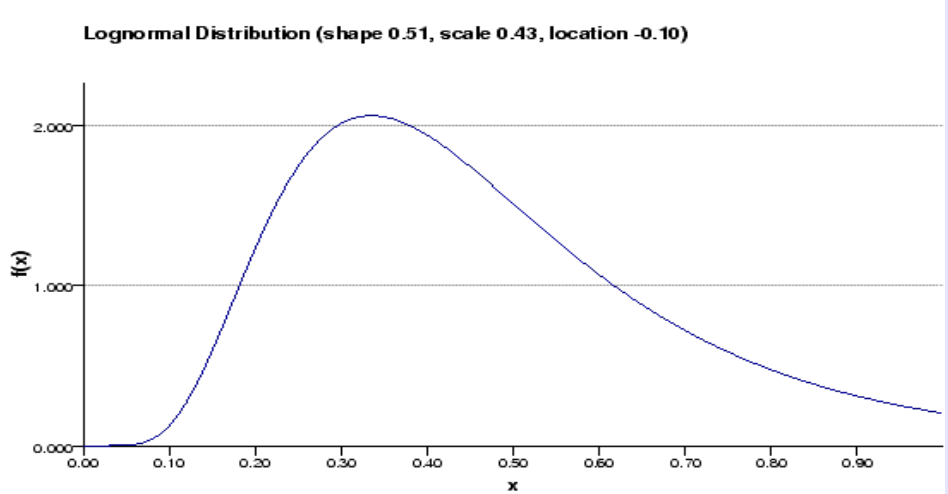
1. What we wanted to find out
2. Preliminary findings (as of S07 meeting)
3. Derivation of norms from statistical model
4. Example
5. Proposed simplified method
6. Testing now in progress
7. Plan for S08

What We Wanted to Find Out

Can we find a sound statistical basis for deriving norms for LTC combustible gas ratios?

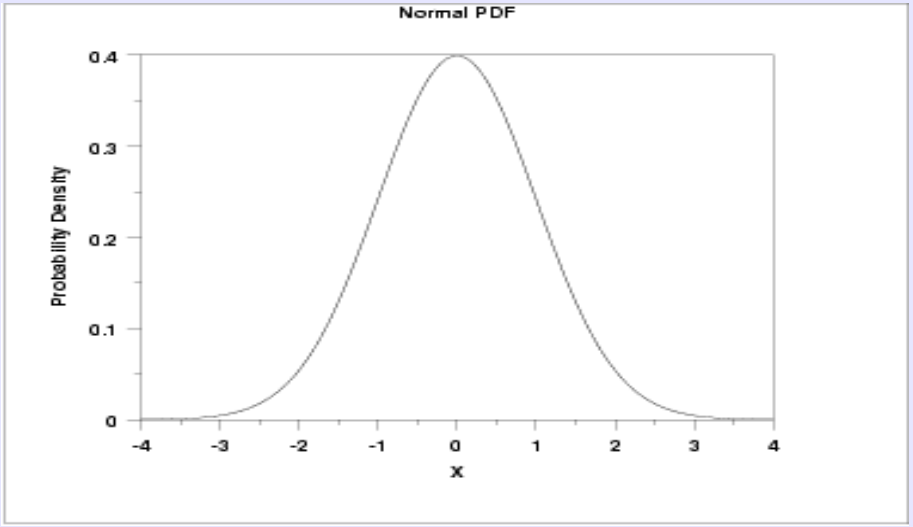
Preliminary Findings (as of S07)



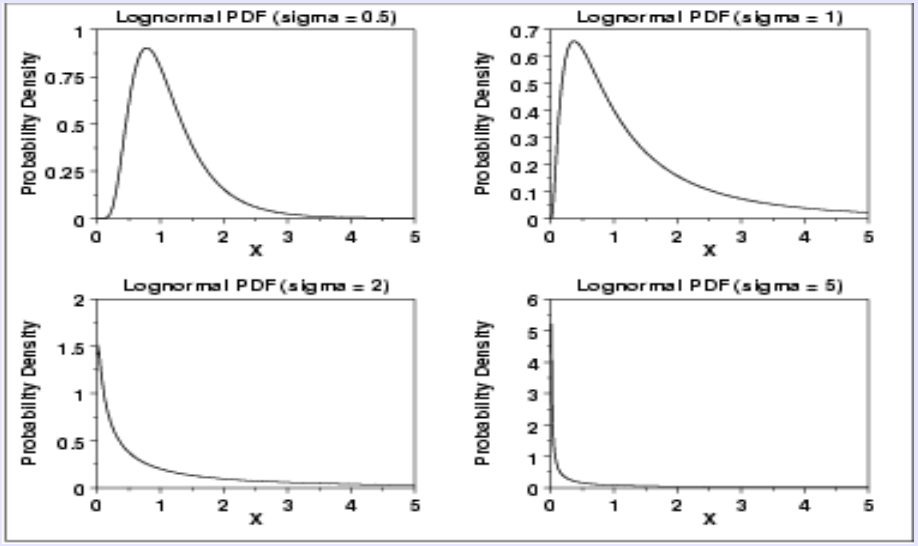


- The main gas ratios seem to fit a lognormal distribution, if extreme values are ignored
- The extreme values are assumed to be caused by LTC faults
- It does not seem to matter much whether the analysis includes multiple years
- Shape of the lognormal distribution depends on LTC type and ratio

What is a Lognormal Distribution?

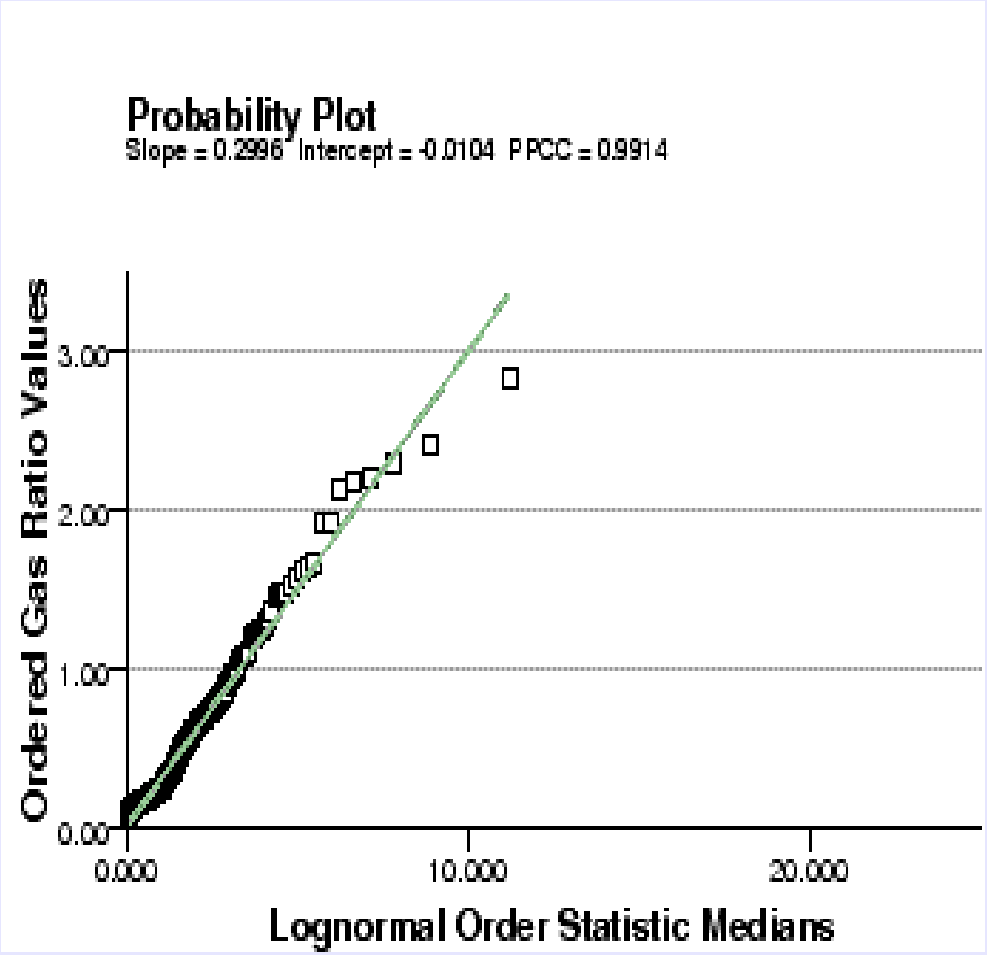


A population of measurement data is lognormally distributed if the **logarithms** of all the numbers fit a **normal** (Gaussian) distribution.



Typically, most of the values in a lognormal distribution are concentrated near zero, with a long "tail" of much rarer high values.

Fitting a Distribution to Data

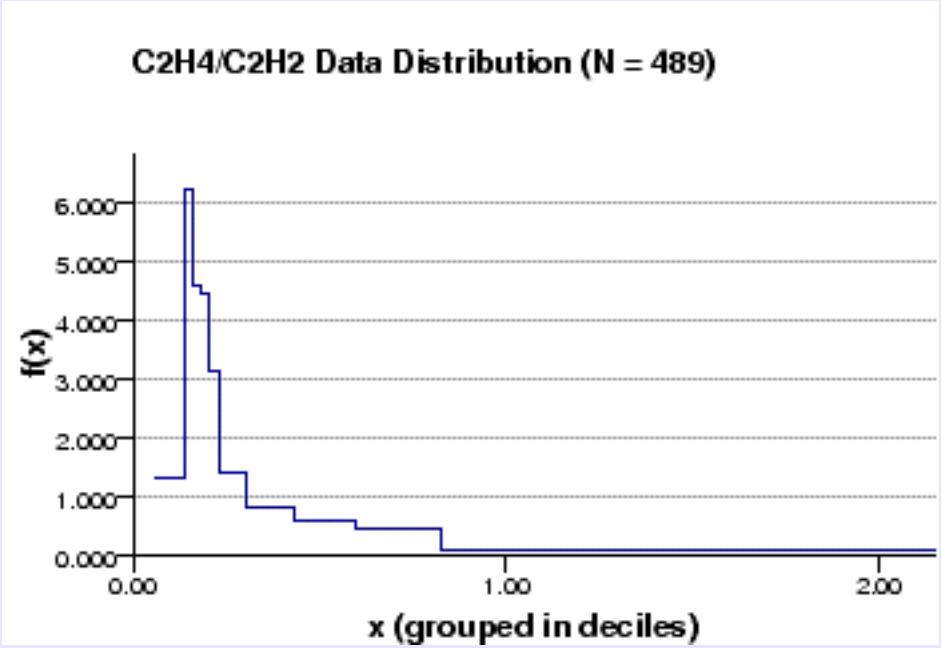


There are many ways to fit a model (probability distribution) to a data set and evaluate its "goodness of fit."

We mainly used the Probability Plot method, where individual dots represent the data and a "regression line" fitted to the dots represents the model.

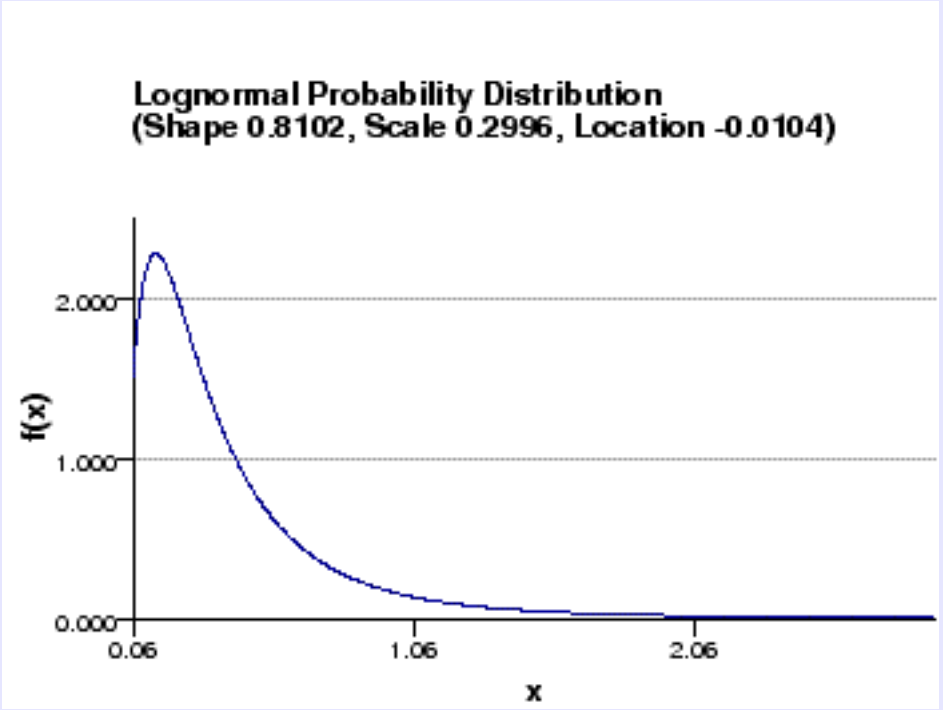
If the correlation coefficient for the regression is very close to 1.0, then the model fits.

Fitting a Distribution to Data



The Data

The Model



Derivation of Norms from Statistical Model

Based on our finding that lognormal distributions can be used to model LTC gas ratios, we experimented with deriving "norms."

- Work with one LTC type, ratio, and data set at a time.
- Remove extreme values.
- Fit an optimized lognormal model to the remaining data.
- Use "percent points" of the model (like percentiles of data) to get candidate values for norms.

PLEASE NOTE: *Statistically derived norms may need to be "tweaked" for performance relative to testing & maintenance budget, business objectives, operating conditions, etc.*

Possible Simplified Derivation Method

- Based on what we have learned so far, it seems possible that a simplified approach might work for deriving norms.
- The idea amounts to calculating the parameters of a slightly less than optimal lognormal distribution directly from the data, and using percent points of that model for norms.
- The simplified approach, if we can confirm that it produces useful results, can be published as a "recipe" which requires only spreadsheet assistance.
- Details are shown after the following example.

Example

Data set: (unnamed electric utility)

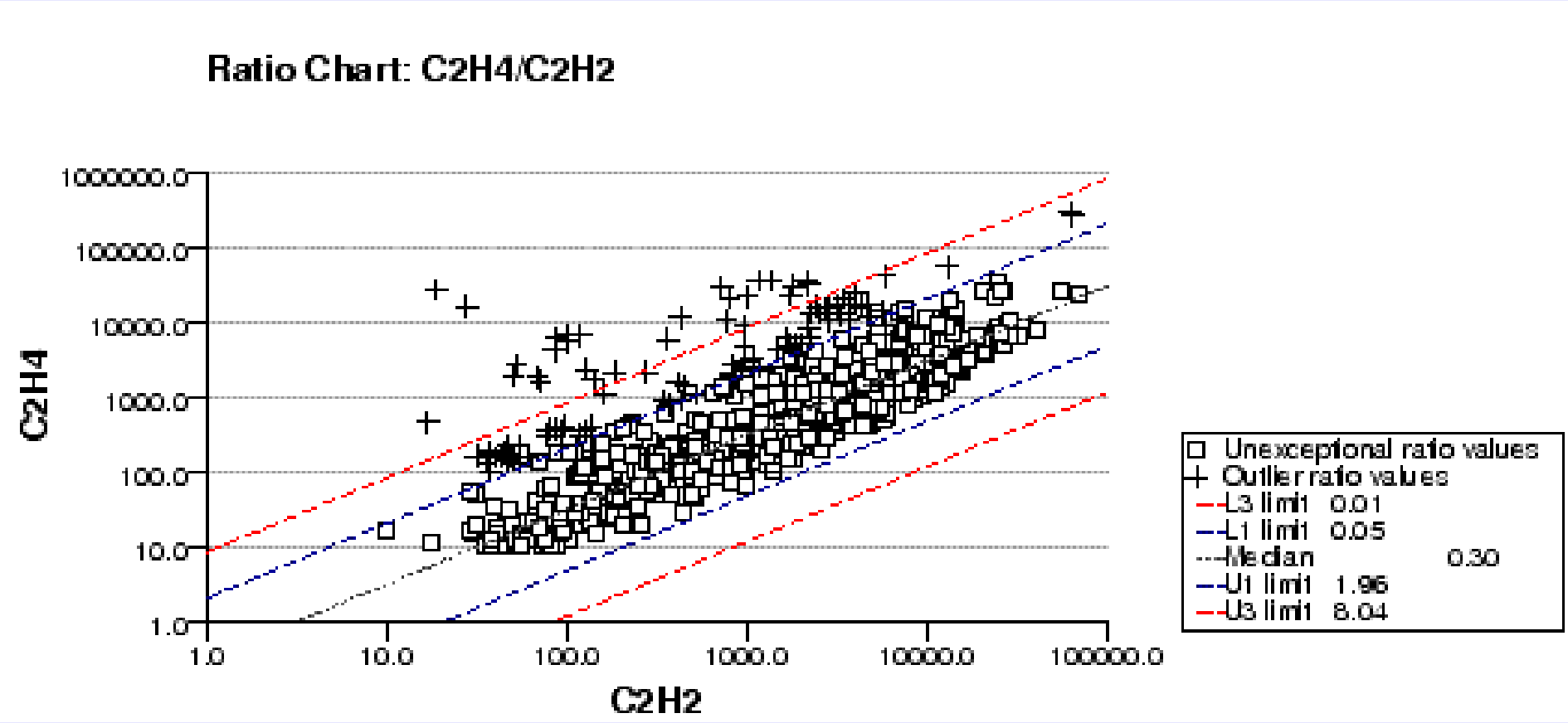
LTC Type: AS1X

Gas ratio: ethylene / acetylene

AS1X - Ethylene/Acetylene

N = **931** with **95** outliers (indicated by plus symbols)

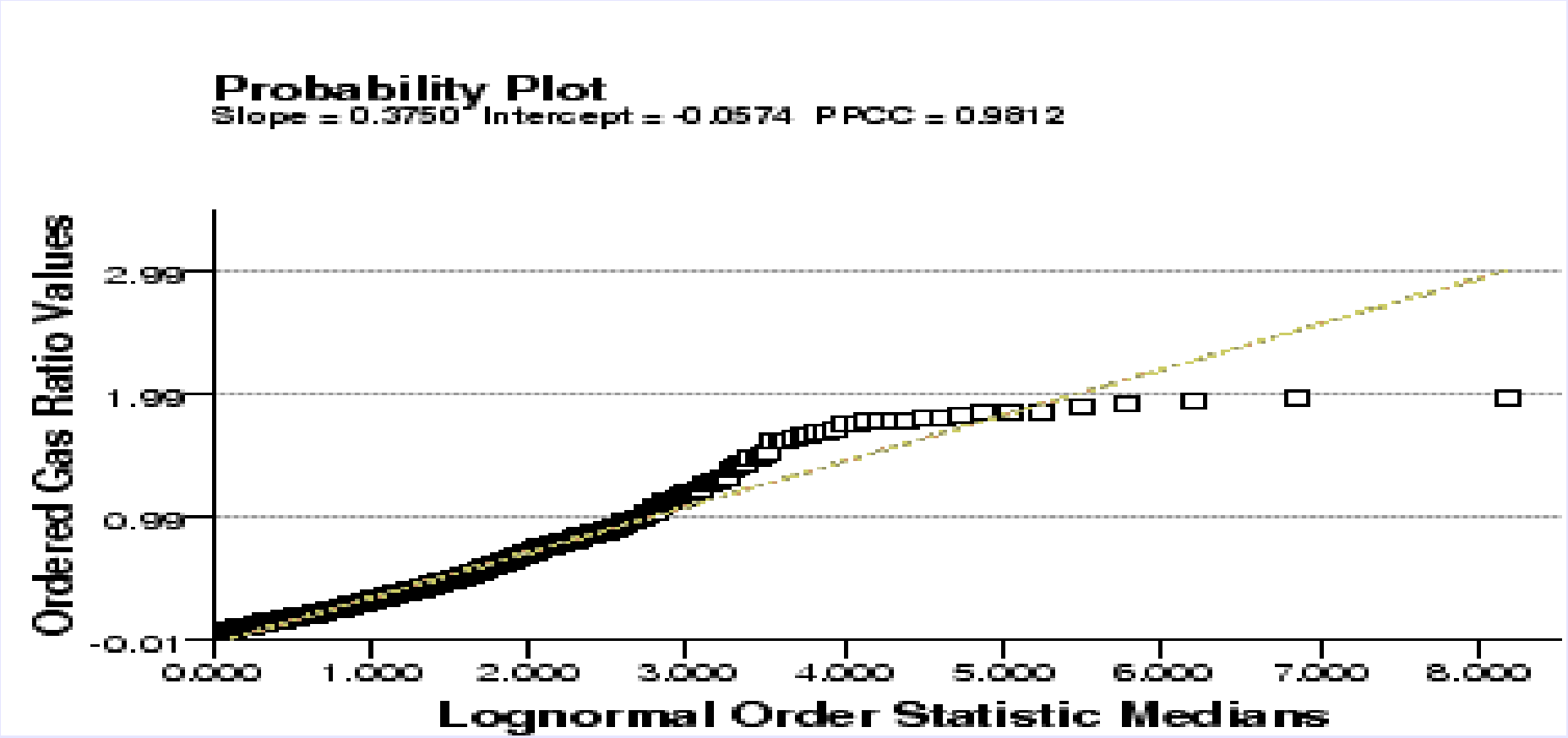
Median ratio value: **0.30**



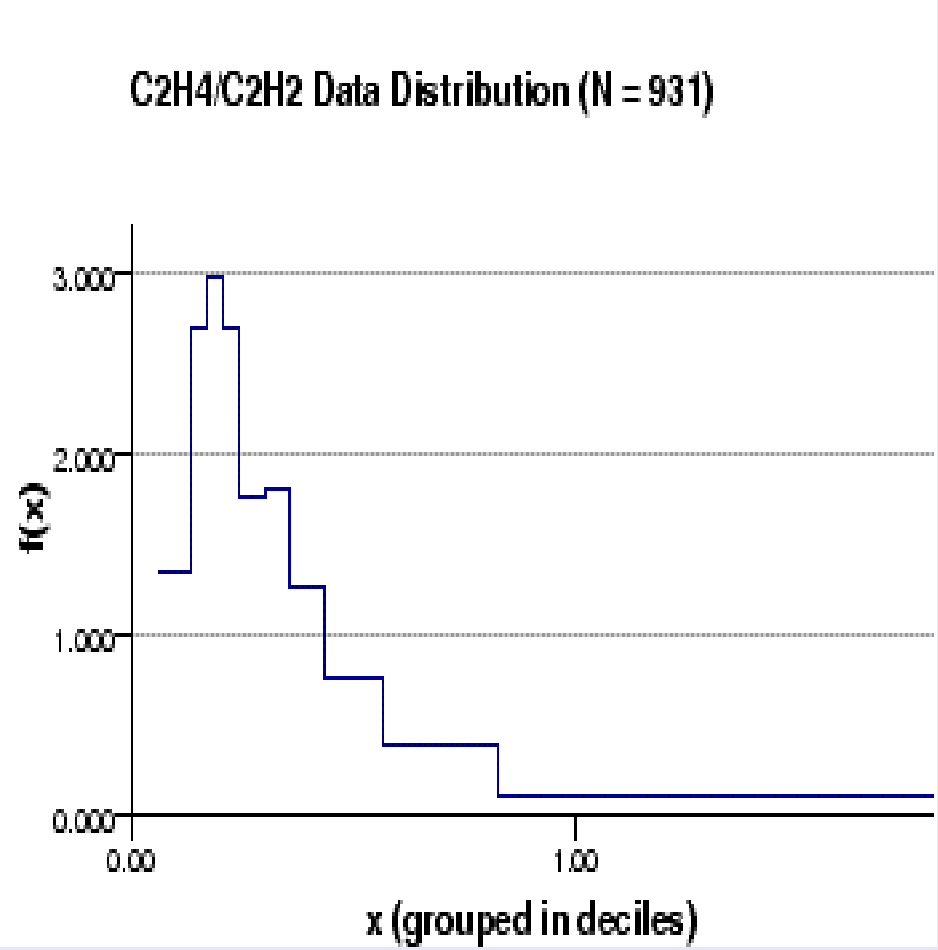
AS1X - Ethylene/Acetylene

Optimized lognormal fit: Locn = -0.06, Scale = 0.38, Shape = 0.66

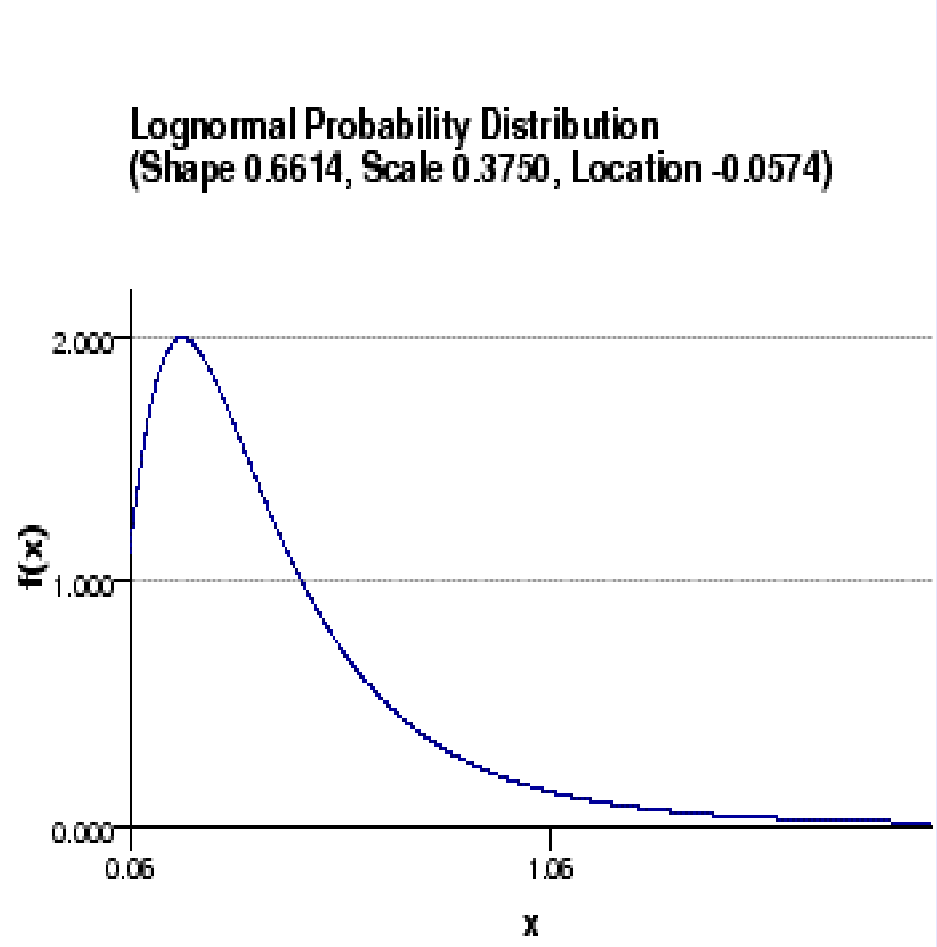
Goodness of fit: Lognormal PPCC = 0.9812



AS1X - Ethylene/Acetylene



The Data



The Model

AS1X - Ethylene/Acetylene

- **Percent points calculated from optimized lognormal distribution**

  C0.95 = 0.94
  C0.99 = 1.48
  C0.999 = 2.45

- **Percent points calculated by the simplified method**

  C0.95 = 0.95
  C0.99 = 1.52
  C0.999 = 2.59

Proposed Simplified Method – p. 1

- Load the ethylene and acetylene values into adjoining columns of a spreadsheet.
- Sort the rows by the ethylene value (descending); delete all rows where ethylene < 10.
- Sort the rows by the acetylene value (descending); delete all rows where acetylene < 10.
- Add a third column containing the ethylene/acetylene ratio, calculated from the first two columns.
- Add a fourth column containing the natural logarithms of the ratios.

Proposed Simplified Method – p. 2

- Sort the rows by the logarithm value (ascending).
- In the fifth column, make cells for calculating these statistics for the logs: first quartile (**Q1**), third quartile (**Q3**), interquartile range (**IQR** = Q3 – Q1), and outlier rejection limits (**L1** = Q1 – 1.5*IQR and **U1** = Q3 + 1.5*IQR).
- Delete all the rows where the log value is less than L1 or more than U1.
- Recalculate Q1, Q3, IQR, L1, and U1 based on the remaining log values, and delete all rows where the log value is less than L1 or more than U1.
- Repeat the step above until no more rows are eliminated.

Proposed Simplified Method – p. 3

- Lower down in the fifth column, make cells for calculating
  M = median of all the remaining log values
  S = IQR / 1.34898
- Make more cells to calculate these percent points:
  C0.95 = exp(M + 1.65*S)
  C0.99 = exp(M + 2.33*S)
  C0.999 = exp(M + 3.09*S)
- These percent points should usually be reasonable "initial guesses" at appropriate norms for the chosen ratio, for the given population of LTC's, provided that N > 30.

Testing Now in Progress

We are deriving experimental norms for various populations of LTC's and checking case histories to see how effective those norms are at identifying faulty LTC's.

Plans for S08

If all goes well, we expect to be able to present a draft DGA guide for LTC's in spring 2008, based on the use of a few combustible gas ratios for fault detection and severity assessment, and presenting (in an appendix) some version of the simplified method for deriving gas ratio norms.

Fault detection for vacuum-type LTC's will be based on gas concentration limits.

Questions

?