Improving the Acceptability of Flow Measurements

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Improving the Acceptability of Flow Measurements

Outline:

1. Background
2. The CIPM-"MRA"-the Mutual Recognition Arrangement
3. The CIPM Working Group for Fluid Flow (WGFF)
4. WGFF Objectives
5. Current WGFF Plans
6. WGFF Schedules
7. Conclusions

Background:

1. Buyers & sellers need measurements.
2. Today's technologies are expanding market places from local and national to global and international.
3. International trade needs international measurement acceptance.
4. International measurement acceptability needs:
   a.) Recognition of measurement certificates, and
   b.) *Comparability* of national measurement standards.
5. The CIPM/Mutual Recognition Arrangement (MRA)* has 4 a.) and b.) as its objectives.

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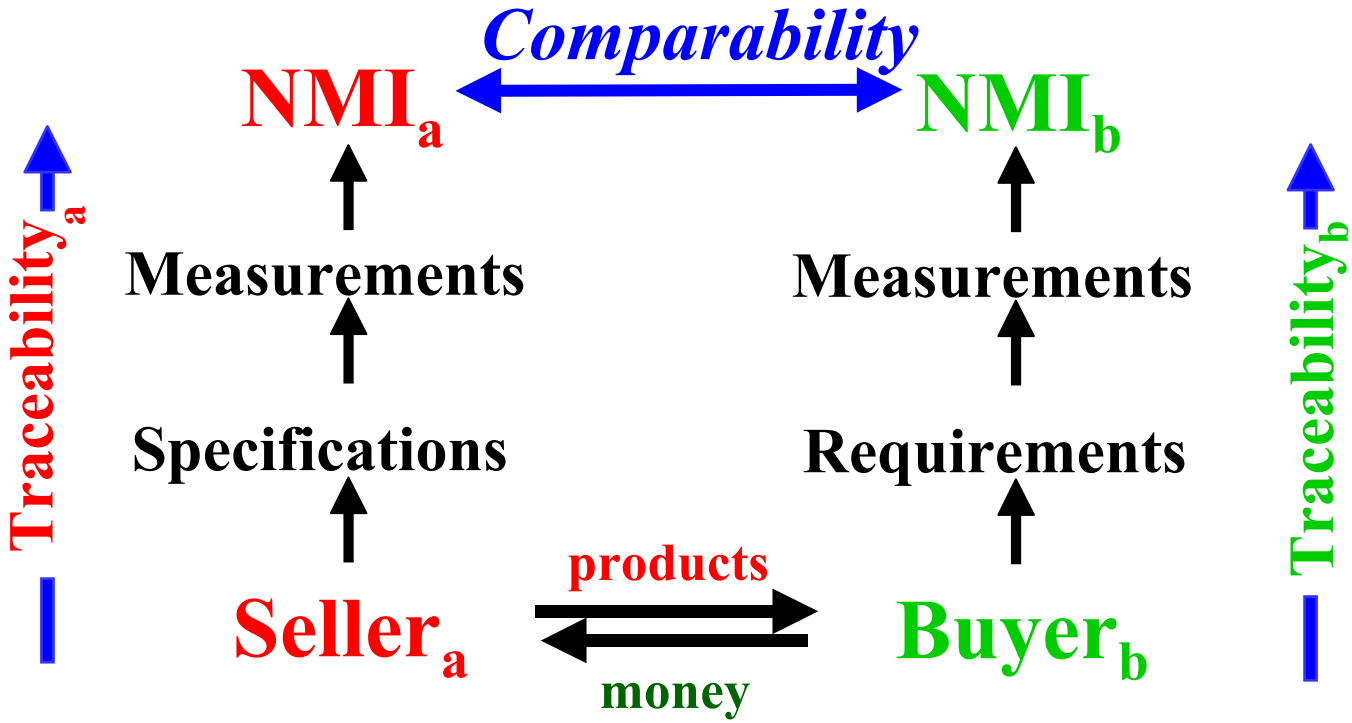
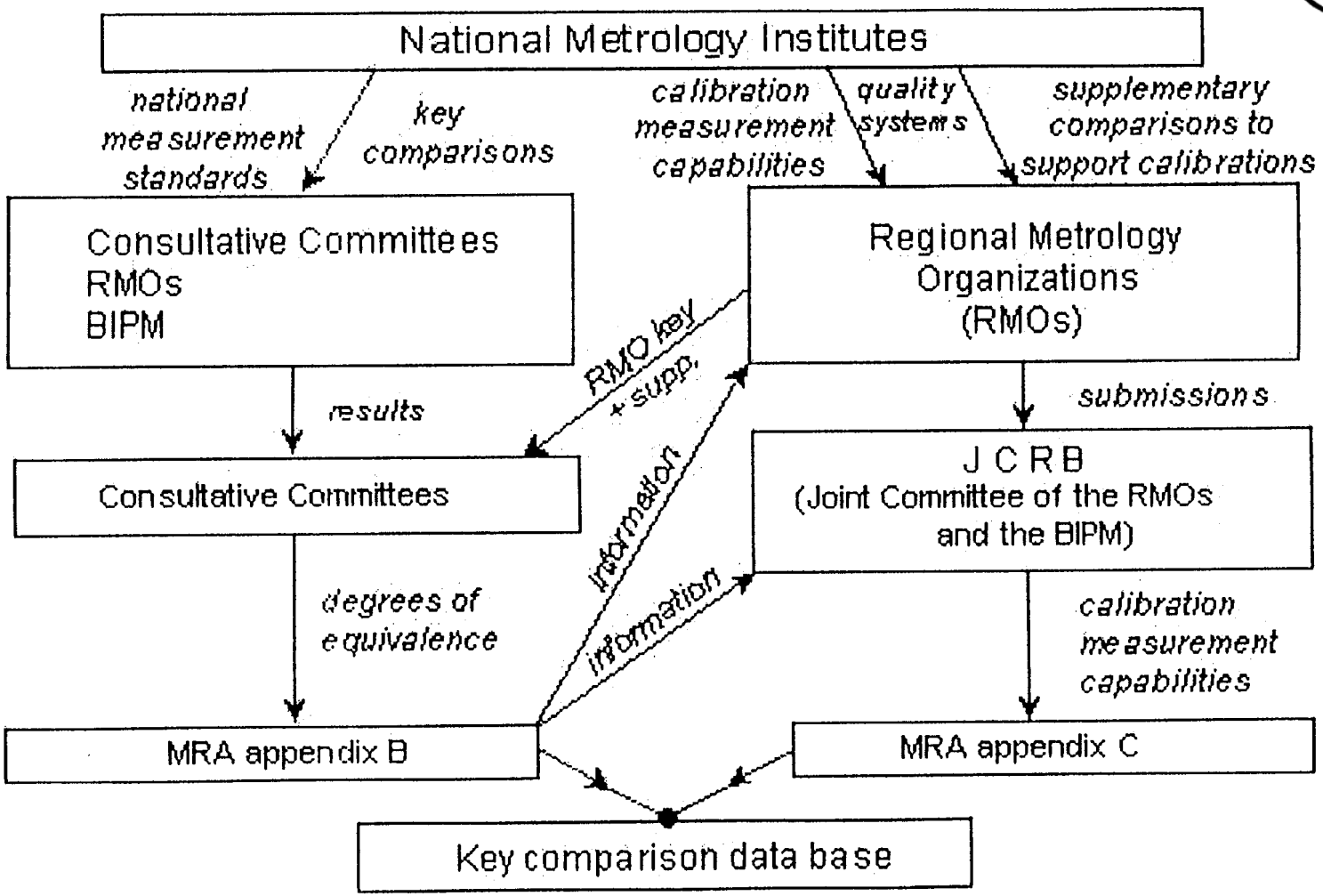
* See: www.bipm.fr

Traceability & *Comparability*:



NMI: National Measurement Institute

Diagram of the MRA



CIPM Consultative Committees (CCs):

1. CCAUV-Acoustics, Ultrasound, and Vibration
2. CCEM-Electricity and Magnetism
3. CCL-Length
4. CCM-Mass and Related Quantities
5. CCPR-Photometry and Radiation
6. CCQM-Amount of Substance
7. CCRI-Ionizing Radiation
8. CCT-Thermometry
9. CCTF-Time and Frequency
10. CCU-Units

Working Groups:

1. Density
2. Mass
3. Force (WGF)
4. Pressure
5. Avogadro's Const.
6. Hardness
7. Fluid Flow (WGFF)
   a. Water Flow
   b. Hydrocarb. Liq. Flow
   c. Hi-Press Gas Flow
   d. Lo-Press Gas Flow
   e. Air Speed
   f. Liquid Volume

MRA Signatories (43):

Argentina
Australia
Austria
Belgium
Brazil
Bulgaria
Canada
Chile
China
Czech Republic
Denmark
Ecuador*
Egypt
Finland
France
Germany
Hungary
India
Ireland
Italy
Japan
Korea
Mexico
Netherlands
New Zealand
Norway
Poland
Portugal
Romania
Russia
Singapore
Slovak Republic
South Africa
Spain
Sweden
Switzerland
Thailand
Turkey
UK
Uruguay
US

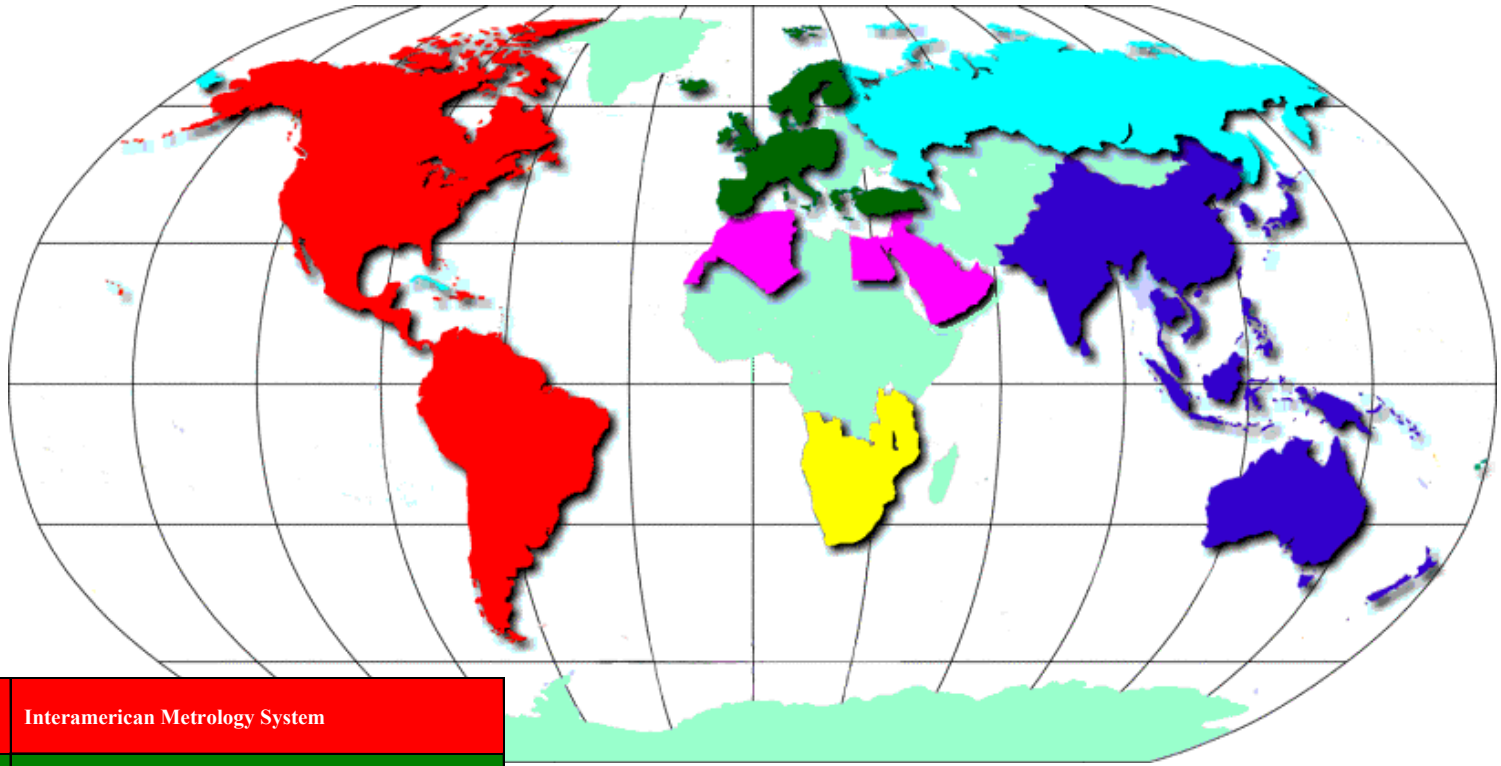
* Associate Member, as of Jan. '01

Int'l Orgs:

Int'l Atomic Energy Agency (IAEA)

Inst. for Refr. Matls and Msmts (IRMM)

Regional Metrology Organizations (RMOs):



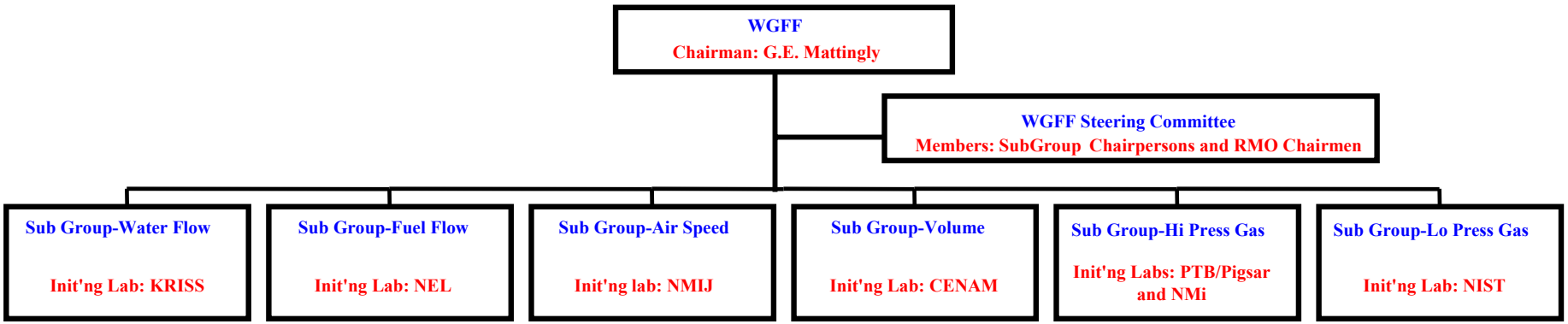
SIM	Interamerican Metrology System
EUROMET	European Union Metrology Cooperation
MENAMET	Middle East & North Africa Metrology
SADCMET	South African Development Cooperation in Metrology
COOMET	Russia, Ukraine, Belarus , Kazakstan , Uzbekistan , Turkmenistan, et al.
APMP	Asian Pacific Metrology Program

NMIs Participating

Measurand	APMP	EUROMET*	SIM
Water Flow	4	16	5
Hydr. Carb. Liq.	4	15	4
Gas Flow (Lo P)	5	14	4
Gas Flow (Hi P)	4	14	2
Air Speed	4	8	2
Volume	4	12	6

* EUROMET and COOMET

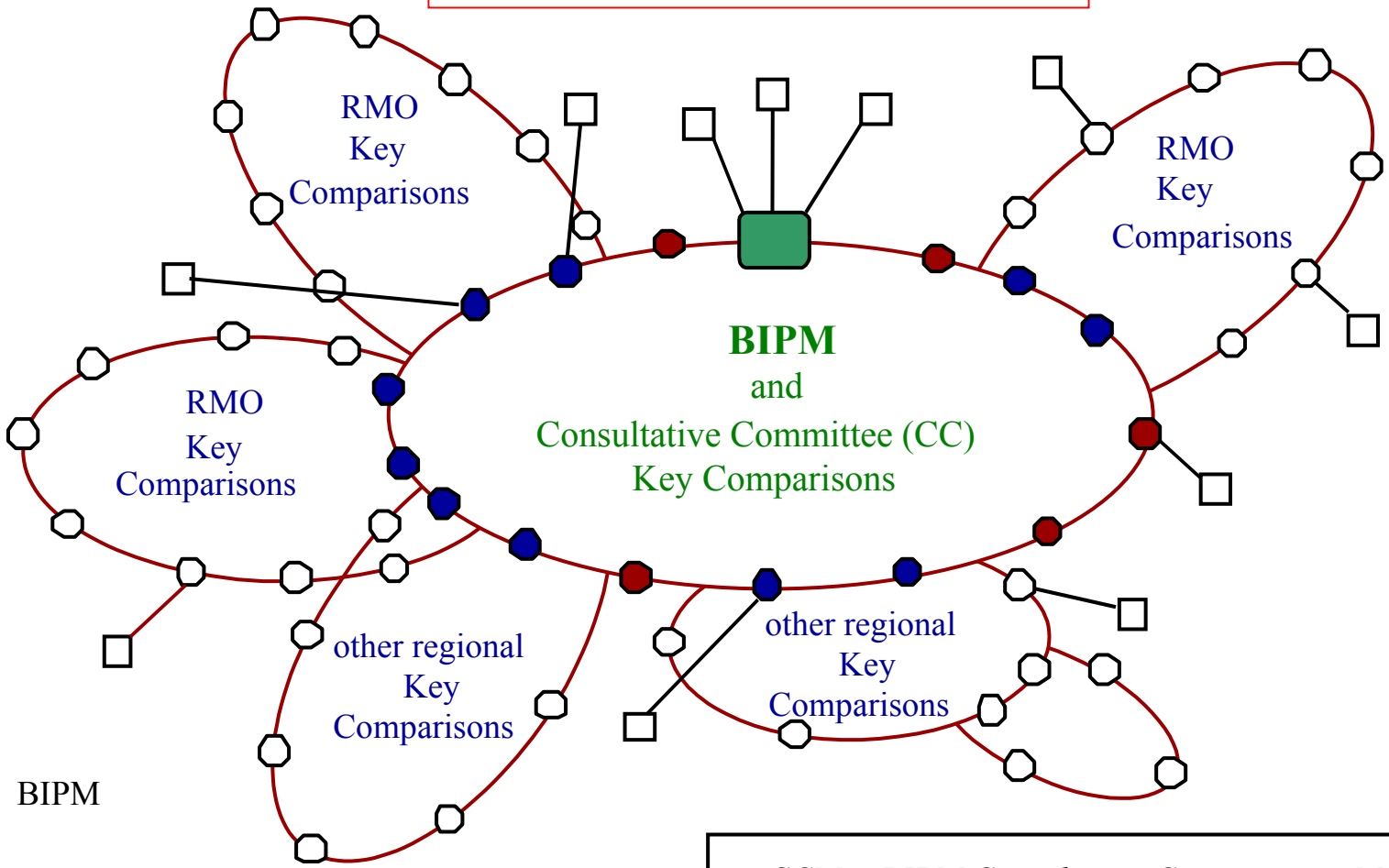
WGFF Structure:



WGFF Responsibilities

Measurand	Initiating Country	Assisting Country	Assisting Country
Water Flow	Korea	UK	Mexico
Hydrocarbon Liquid Flow	UK	Japan	US
Gas Flow (Low P)	US	UK	Korea
Gas Flow (High P)	Germany and The Netherlands	US	Korea
Air Speed	Japan	Brazil	Netherlands
Volume	Mexico	Australia	Sweden

Generic Key Comparison Tests



BIPM

NMI participating in BIPM/CC Key Comparisons

NMI participating in BIPM/CC Key Comparisons and in RMO Key Comparisons

NMI participating in regional Key Comparisons

NMI participating in neither BIPM/CC nor regional Key Comparisons but making bilateral comparisons directly with BIPM or with NMIs in categories , , or

CCM = BIPM Consultative Committee on Mass and Related Quantities

RMOs = Regional Metrology Organizations

NMI = National Metrology Institution

SIM = Systema Interamericano Metrologia

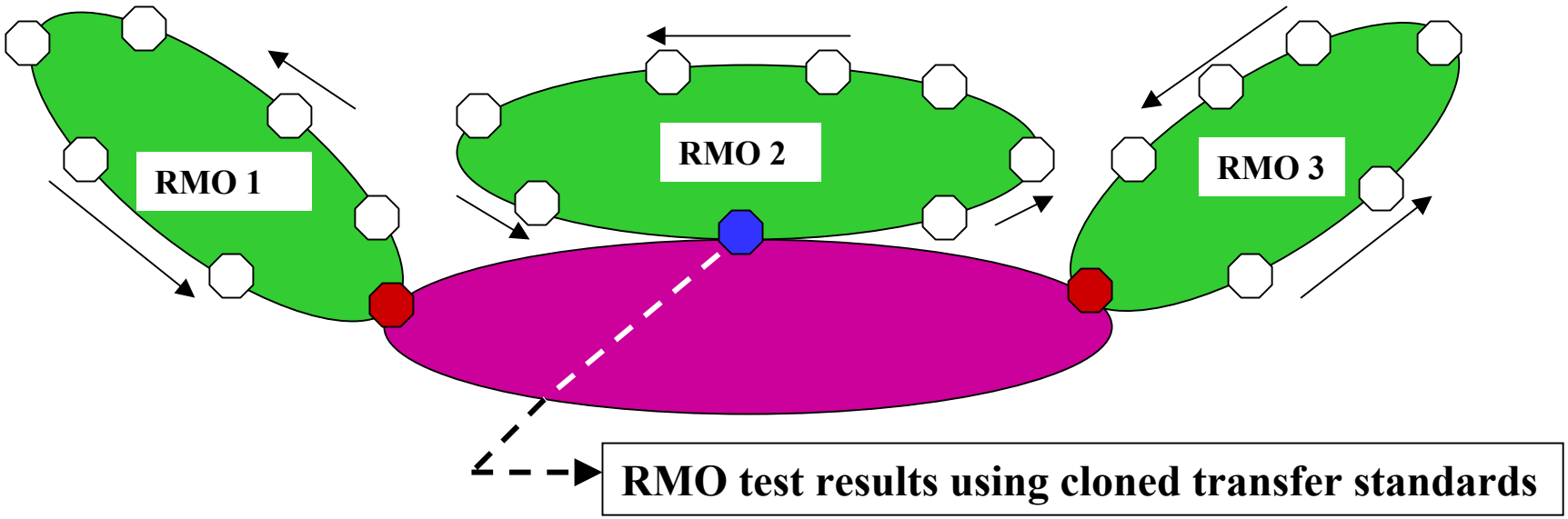
APMP = Asian-Pacific Metrology Program

EUROMET = Metrology Organization of the European Union

Ideal Key Comparison Testing

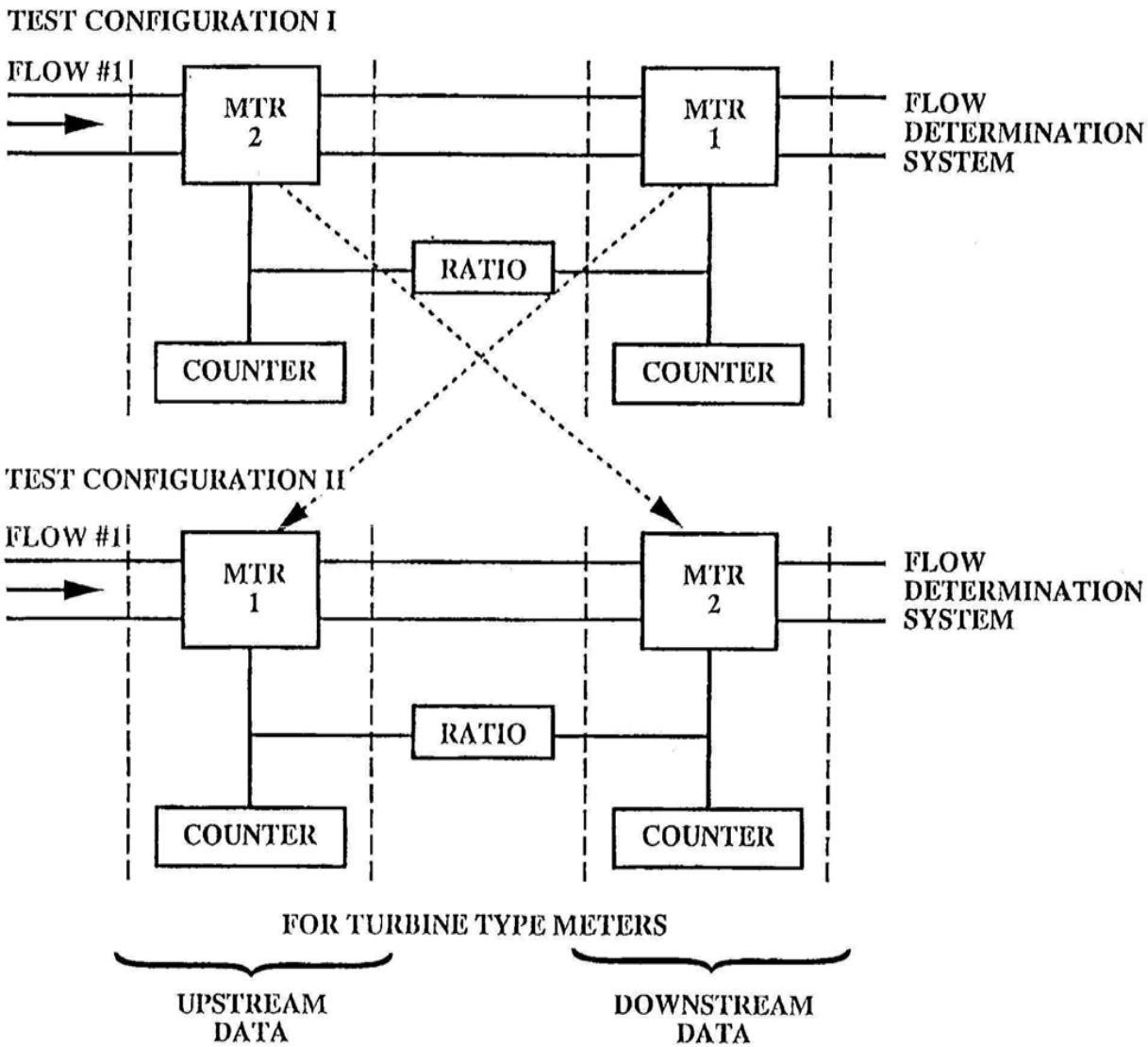
Initial Phase: Initiating Lab produces, tests, and clones the original transfer standard. KC proposed to CCM.

RMO Test Phase: Pilot [ ]and Pivot Labs [ ] arrange, monitor, and complete RMO tests among Signatory NMIs [ ]using cloned transfer standards:



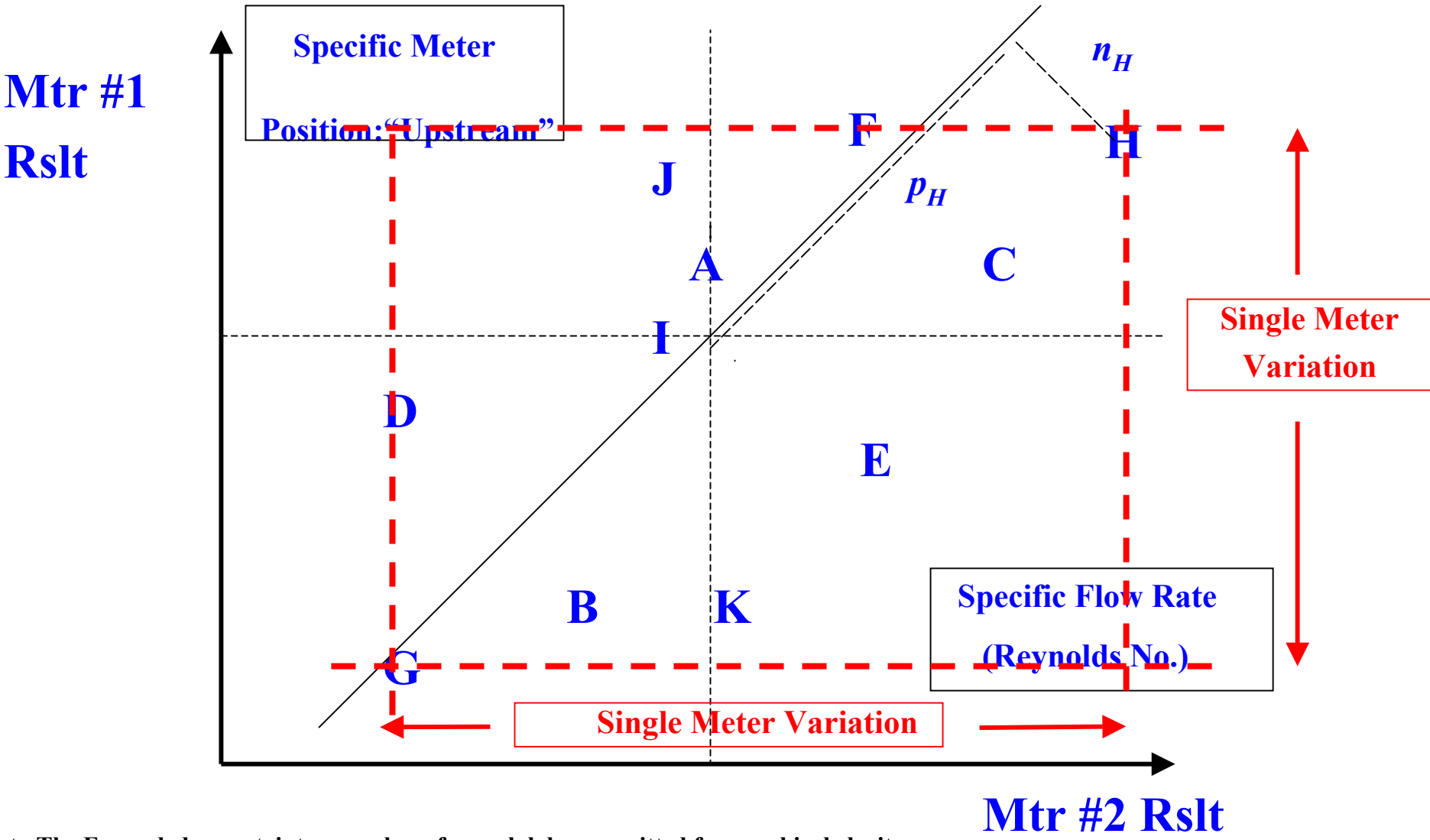
Final Phase: Pilot and Pivot Labs complete "after" tests to assure clone performance; Pilot analyses data and reports results.

"Ideal" CIPM KC Test Procedures:



Sketch of Proficiency Tests Using Tandem Meter Configurations

Youden Graphical Analysis of Variance:



Note:The Expanded uncertainty error bars for each lab are omitted for graphical clarity.

The median lines are drawn for "equally weighted" labs.

Youden Graphical Analysis of Variance:

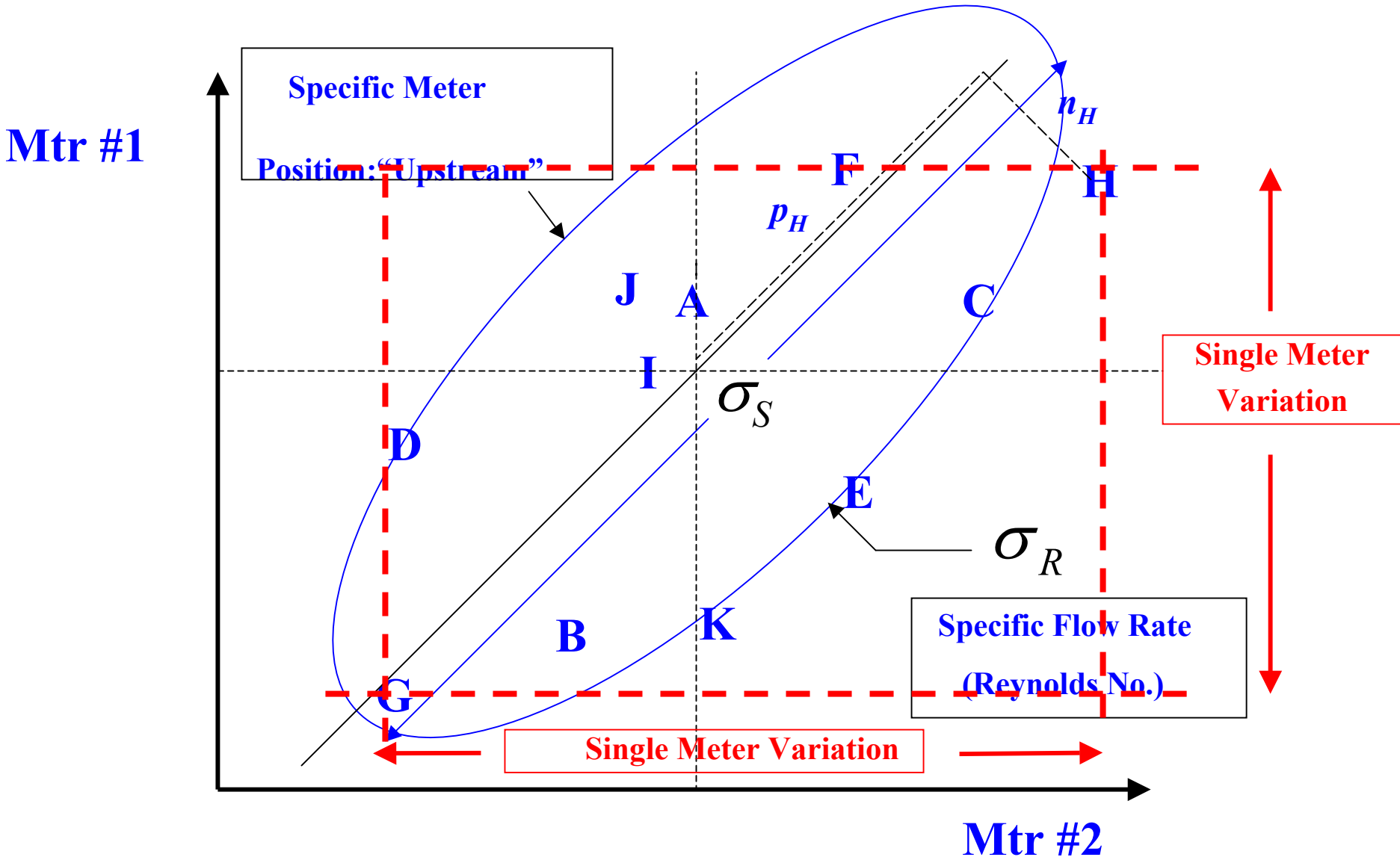
$$\sigma_s = \frac{1}{m-1}\sum_{i=1}^{m} p_i^2$$

...where labs: A,…,I are as *i*: 1,…,m

$$\sigma_R = \frac{1}{m-1}\sum_{i=1}^{m} n_i^2$$

$$\textit{Ellipticity/Circularity} = \sigma_S \Big/ \sigma_R \geq 1$$

Youden Graphical Analysis of Variance:



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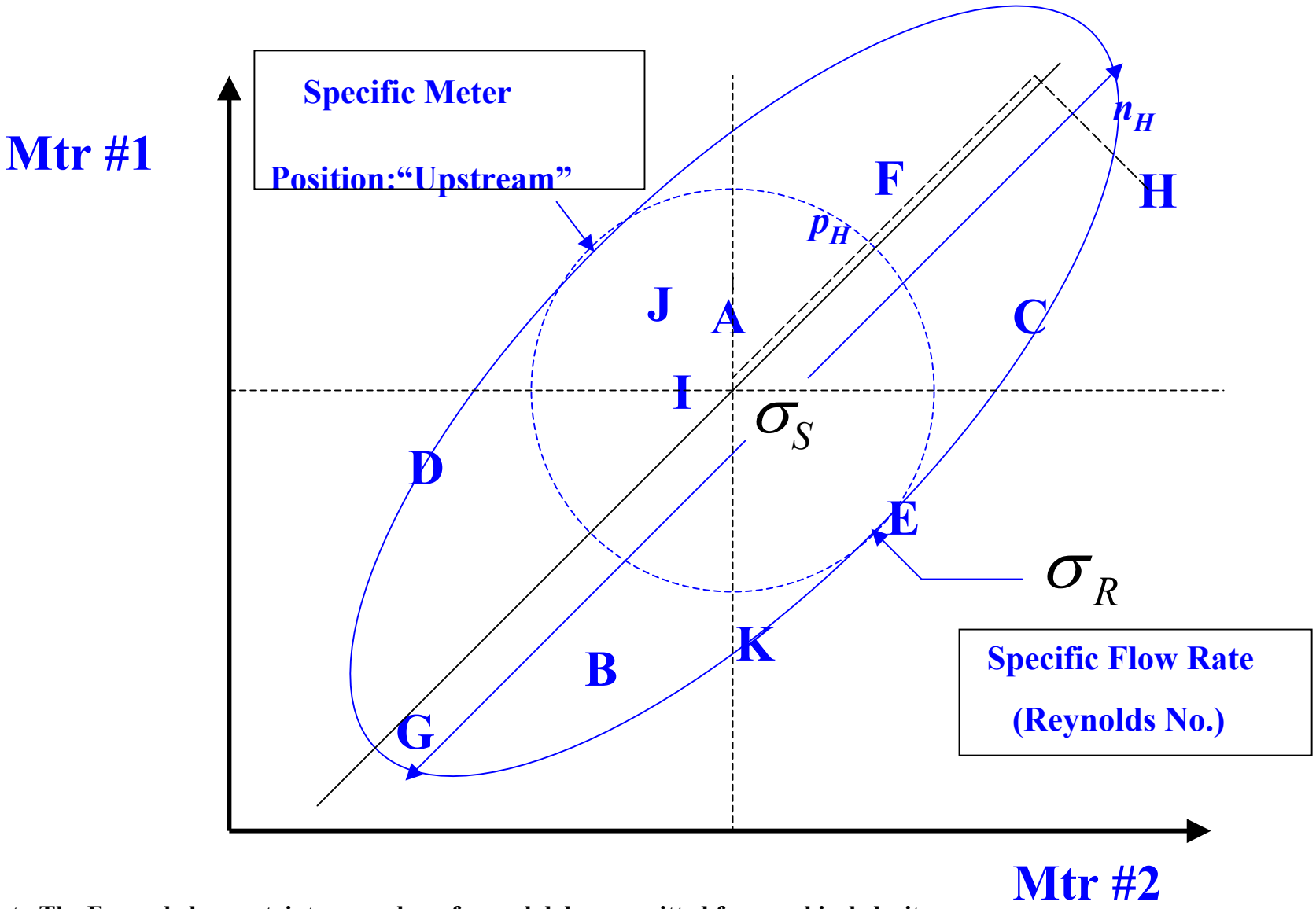

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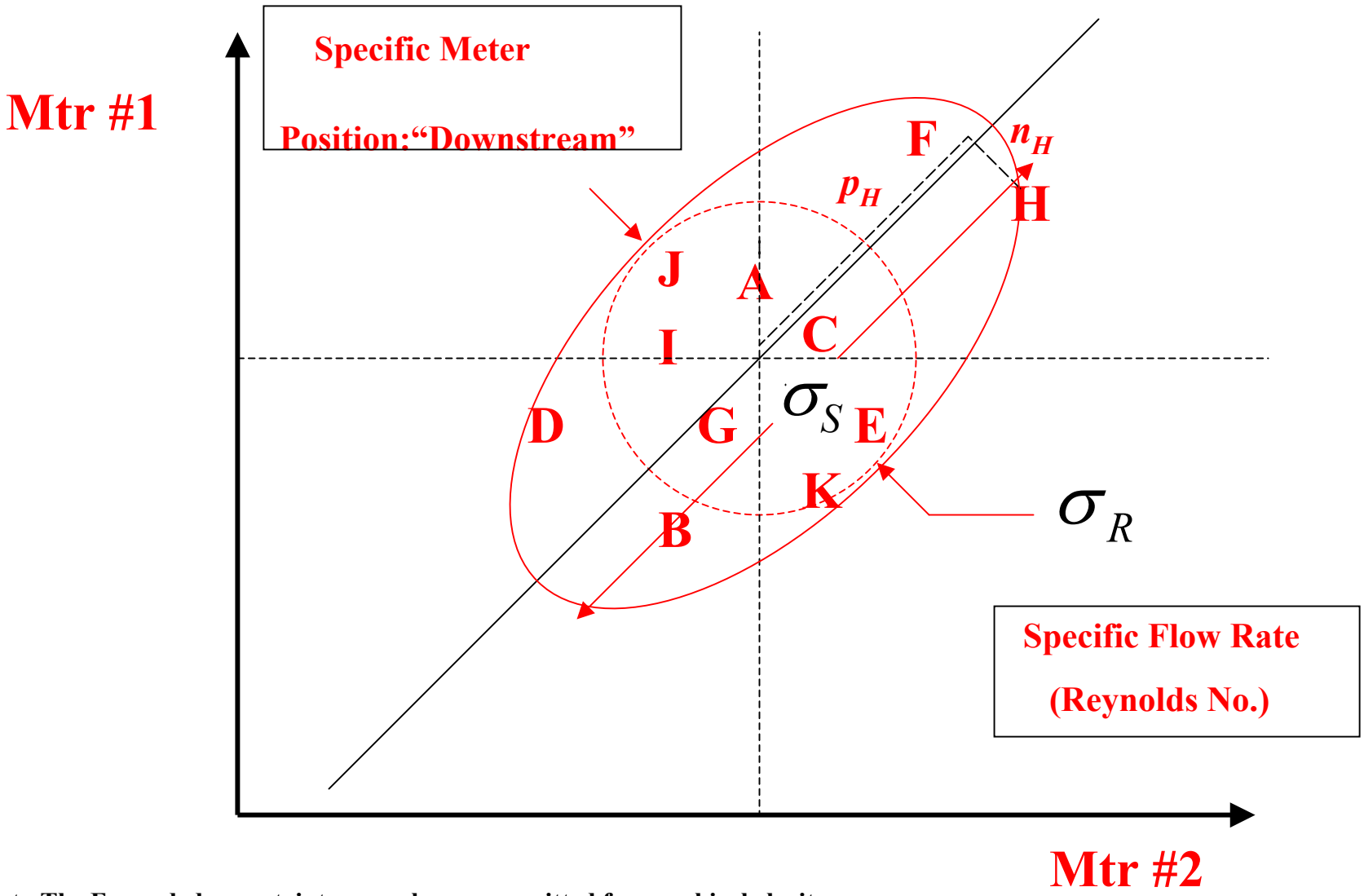

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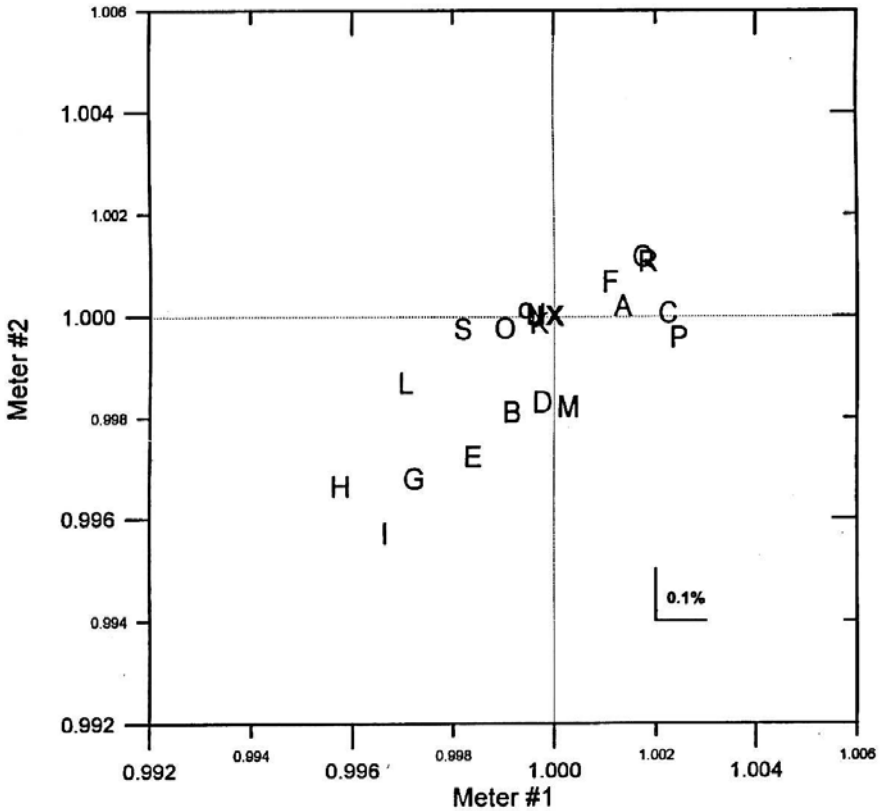
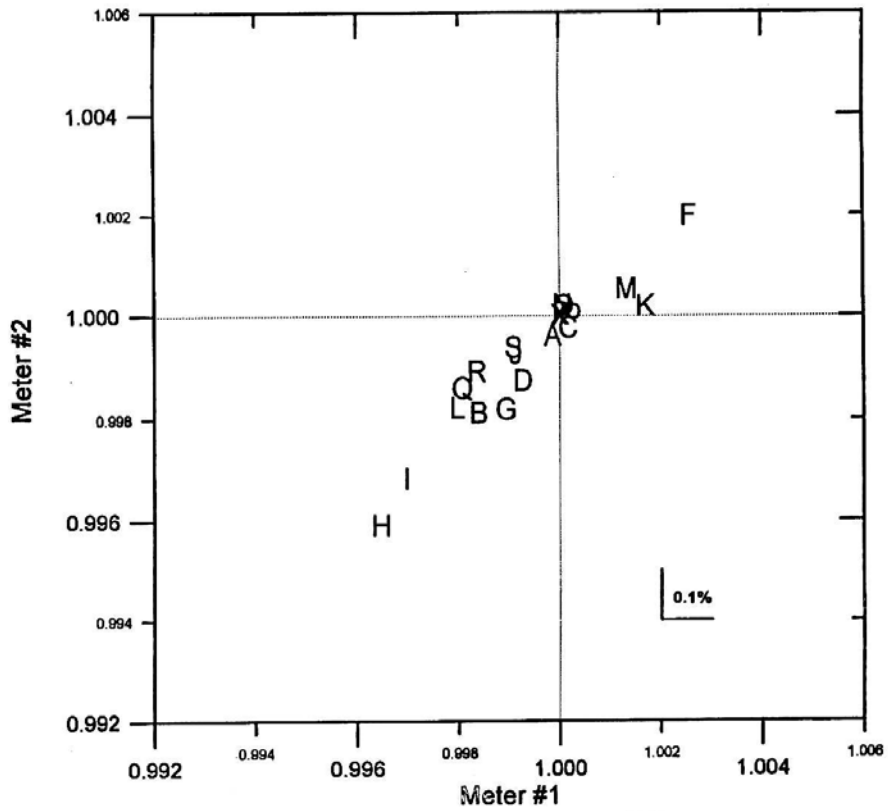


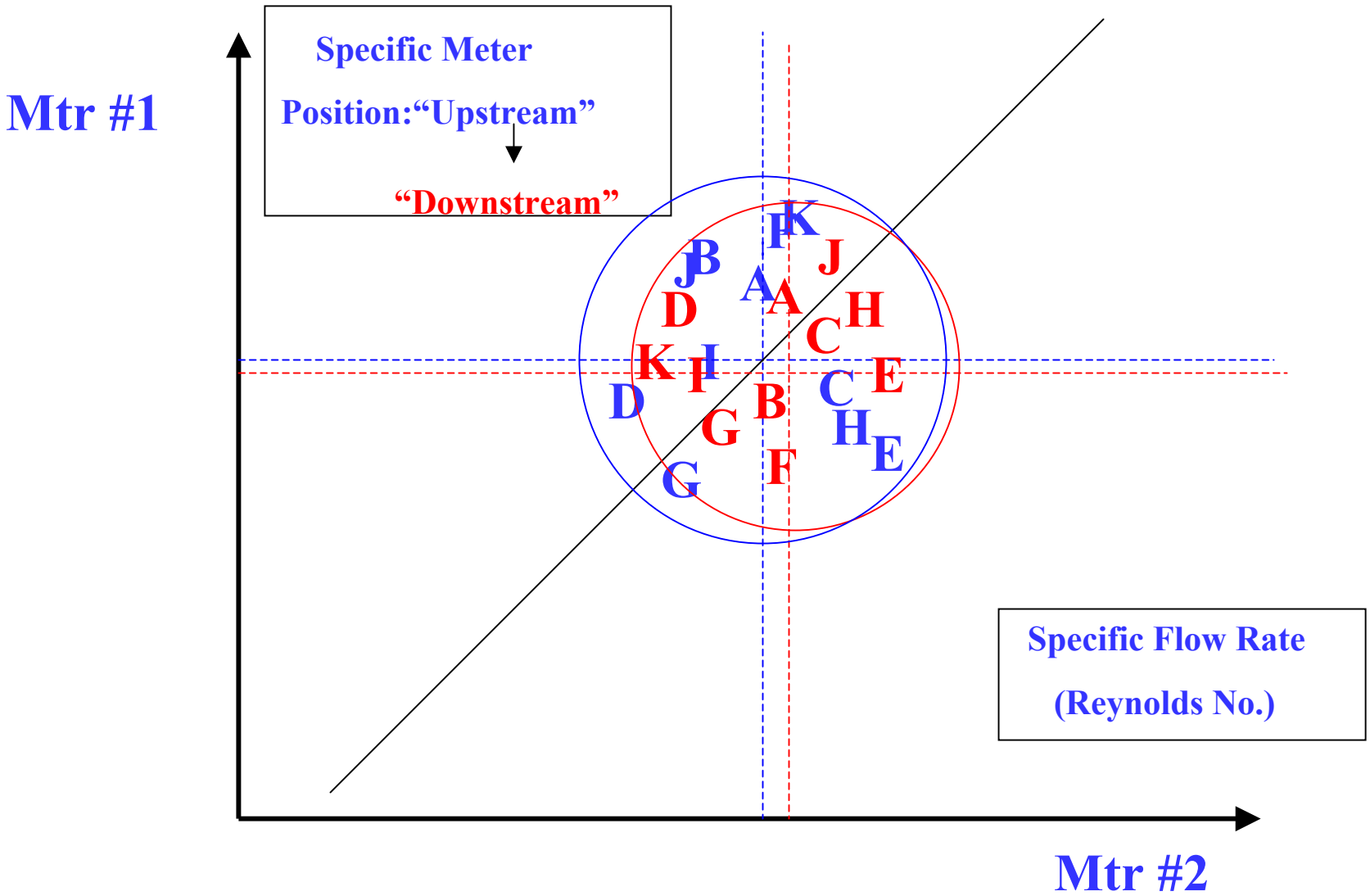
(a) Upstream Meters



(b) Downstream Meters

Round Robin Results for Turbine Meters Flowing Hydrocarbon Liquid for Reynolds Number of 2750: (a) Upstream Meters, and (b) Downstream Meters.

Desired Youden Results:



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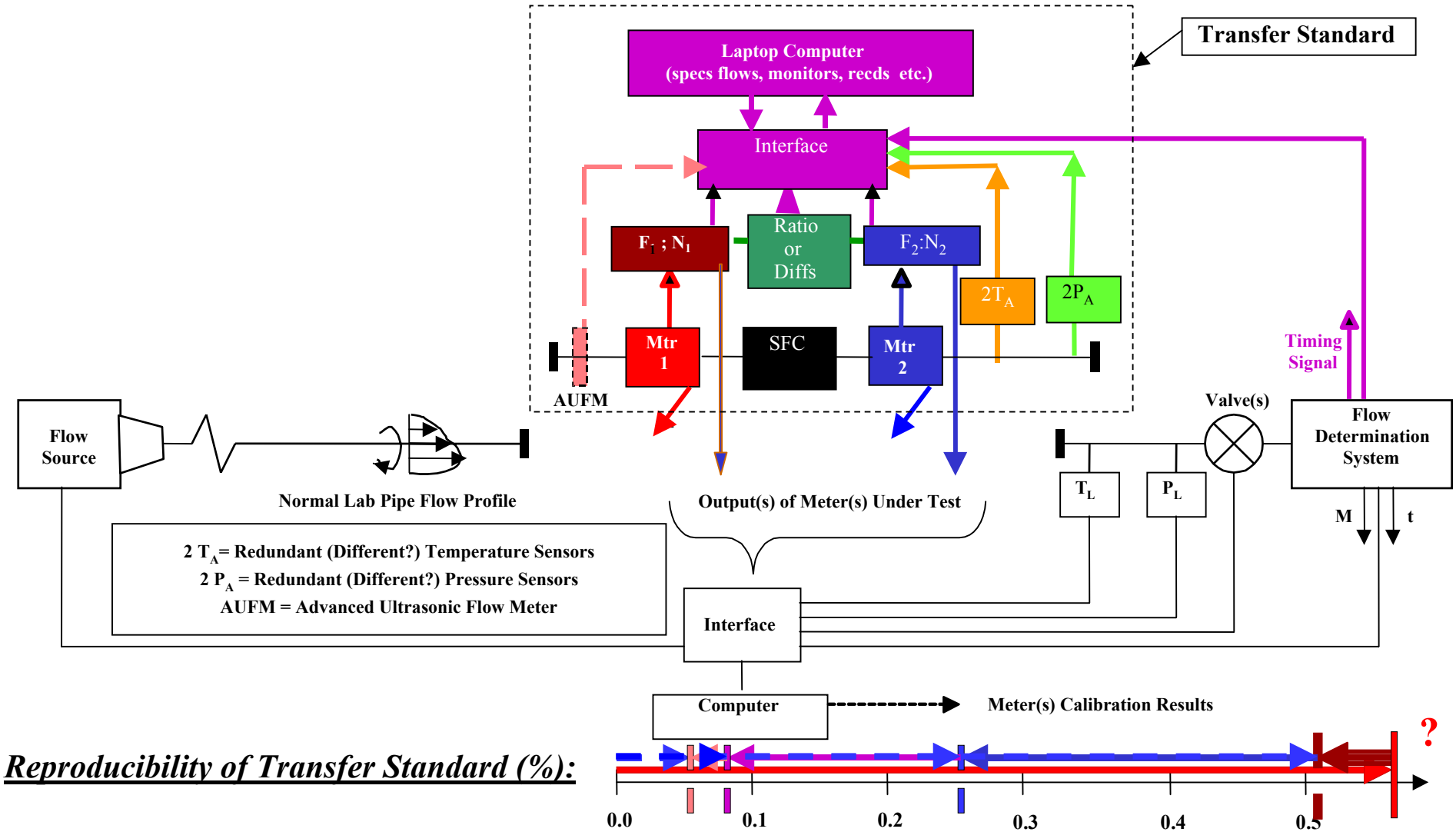
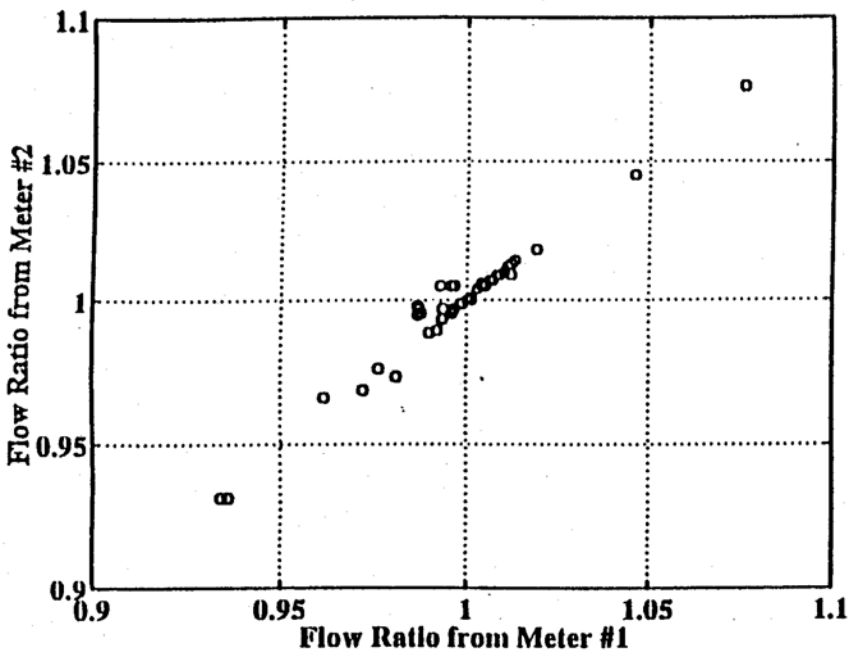
Fluid Flow Rate Measurement

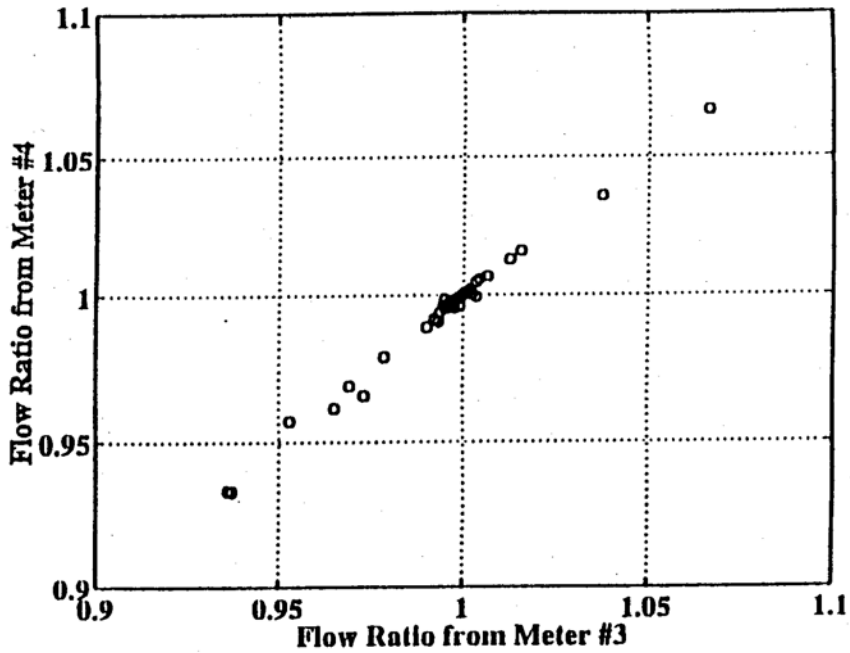
Generic Design for WGFF Transfer Standards for WGFF Key Comparisons



Reproducibility of Transfer Standard (%):



(a) Upstream Nozzles



(b) Downstream Nozzles

Figure 7 Round Robin Results for Critical Nozzles Flowing Nitrogen for a Tube Reynolds Number of 300: (a) Upstream Nozzles, and (b) Downstream Nozzles.

WGFF History and Time-Line:

1998

2/98 NMI directors initial CIPM Mutual Recognition Arrangement (MRA)

6/98 at FLOMEKO '98, AHGF initiated by PTB; NMIs surveyed for interest & standards

1999

Interest in AHGF received at PTB and NMI standards capabilities collected

6/99 at 4th ISFFM, proposed WGFF Structure approved

10/99 at 21st CGPM MRA signed by NMI directors for 4 years; WGFF formed

2000

WGFF Plans produced; invited MRA Signatory NMIs to join WGFF

3/00 EUROMET Mtg; WGFF plans discussed

6/00 1st WGFF Meeting; NMI responsibilities accepted; KC tests discussed

1. Appendix C Reviews started
2. KC test conditions and Generic Transfer Standard designs discussed

2001

MSC2001 Presentation

4/02 2nd WGFF ; *CMC Reviews and TS design discussions continued*

ASME, IMEKO, and NCSL Presentations

2002

SIM meeting

Transfer Standards' constructed and assessments started; KCs tests to begin ASAP

EUROMET meeting

2003+

4/07-11 5th ISFFM planned for Wash. DC; 3rd WGFF meeting planned to review progress, etc.

KC tests completed ASAP; Data Analysis; Draft repts written, rev'd, and sent to CCM/CIPM

FLOMEKO planned for Groningen, The Netherlands; WGFF meeting planned: initial KC results reported, and sequel activities initiated

MRA 4 year signing period ends

Conclusions:

1. Goals of MRA and WGFF are realistic,
2. WGFF organization and plans can achieve metrological requirements for KCs,
3. WGFF strategies should achieve objectives within temporal guidelines,
4. KC Database should eliminate “measurement-based barriers” to international trade, and
5. Subsequent tests can expand conditions and database, as needed.