Bulletin OIML n° 85
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Trimestriel

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L'ORGANISATION INTERNATIONALE DE MÉTROLOGIE LÉGALE

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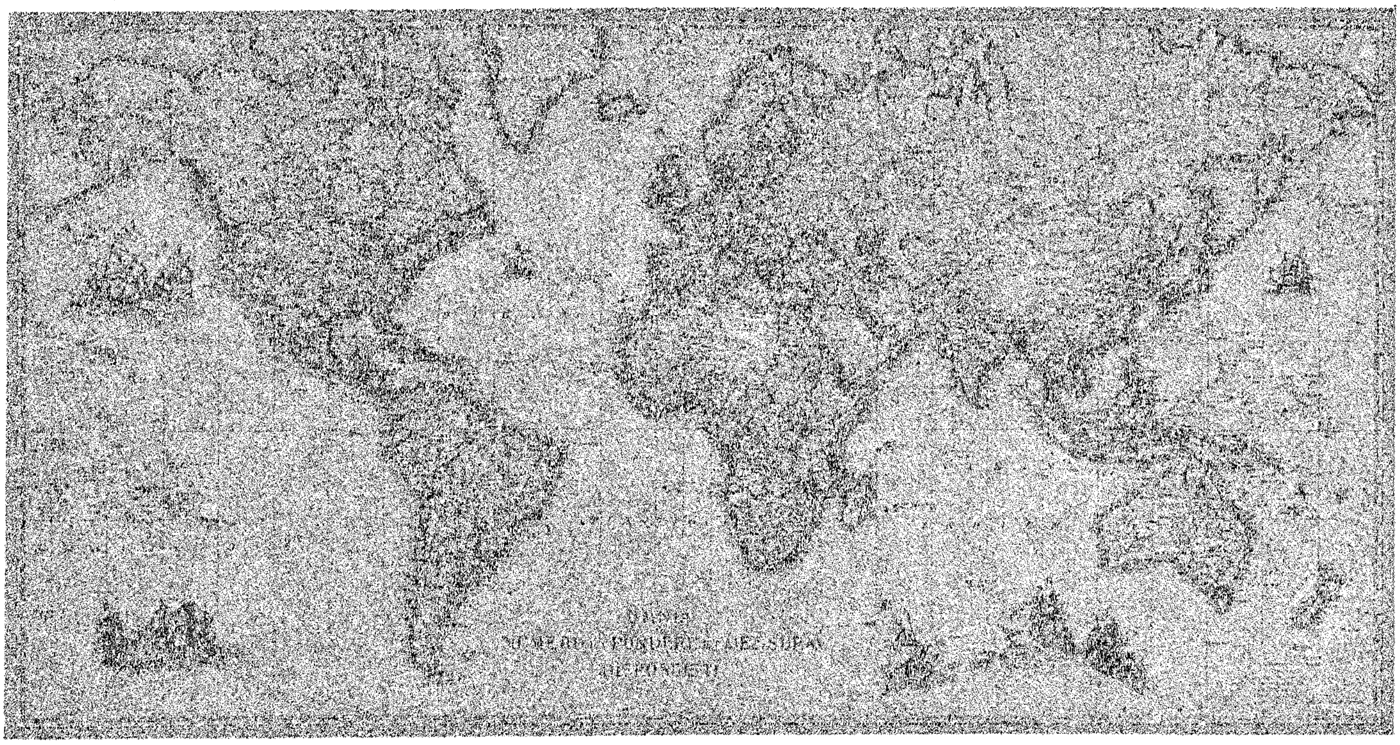

BUREAU INTERNATIONAL DE METROLOGIE LEGALE
11, Rue Turgot — 75009 PARIS — France

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de
l'ORGANISATION INTERNATIONALE de MÉTROLOGIE LÉGALE

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FRANCE

ANALYSE du 1er CIRCUIT INTERNATIONAL de DOSAGE de l'EAU dans les CÉRÉALES

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Service des Instruments de Mesure
Ministère de l'Industrie

I. Introduction

Le dosage de l'eau dans les céréales et les oléagineux est une opération capitale présentant un intérêt multiple :

— intérêt technologique, pour la détermination et la conduite rationnelle des opérations de récolte, de séchage, de stockage, ou de transformation industrielle ; c'est un paramètre essentiel pour l'évaluation et la maîtrise des pertes après récolte ;

— intérêt analytique, pour rapporter les résultats des analyses de toute nature à une base fixe (matière sèche ou teneur en eau du grain aux normes) ; en particulier l'évaluation de l'importance pondérale d'un stock exige une connaissance précise de la teneur en eau ;

— intérêt commercial ; les contrats d'achat et de vente stipulent en général, tant au niveau des échanges intérieurs d'un pays qu'au niveau des échanges internationaux, soit la limite supérieure de teneur en eau à ne pas dépasser soit les barèmes de réfaction et de bonification en fonction de la teneur en eau mesurée ;

— intérêt réglementaire enfin ; les réglementations nationales fixent généralement pour des raisons de bonne conservation des grains et d'honnêteté commerciale, les teneurs en eau limites des grains faisant l'objet d'échanges.

Ces deux derniers points expliquent le choix qu'a fait l'OIML d'inscrire au sein du SP 18 « Mesurage des caractéristiques des produits alimentaires », un secrétariat rapporteur SR 1 relatif aux « humidimètres pour grains de céréales et graines oléagineuses ». En tant que responsable de ce secrétariat, le Service des Instruments de Mesure français a rédigé successivement trois avant-projets de Recommandation Internationale qui ont fait l'objet de réunions internationales en 1977 et 1979 ; la dernière réunion a eu lieu à Paris, en octobre 1981, pour examiner le 4e avant-projet.

A l'occasion de la réunion d'octobre 1979, les « méthodes de référence » qui sont destinées à déterminer la teneur en eau conventionnellement vraie des échantillons de grains utilisés pour l'étalonnage et le contrôle des humidimètres, ont fait l'objet de longues discussions. Les méthodes de référence proposées dans le 2e avant-projet de Recommandation sont les méthodes normalisées par l'ISO, mais plusieurs pays, en particulier les U.S.A. et le Danemark sont en désaccord avec ces normes.

Aussi a-t-il paru utile de mettre en place une intercomparaison des laboratoires internationaux et des méthodes de référence utilisées par chacun d'eux. C'est pourquoi la France a proposé d'organiser, avec l'aide financière du BIML et le concours de l'INRA (*), l'ITCF (*) et le BIPEA (*) un circuit international de dosage de l'eau ; cette proposition a été accueillie avec enthousiasme par la grande majorité des participants.

II. But recherché

L'intérêt de ce circuit était multiple :

— il a permis d'établir une intercomparaison des laboratoires officiels de chacun des Etats participants, consistant en l'analyse par chacun de ces laboratoires d'échantillons de grains provenant d'un même lot ; il s'agissait de voir si les méthodes de référence définies par l'ISO permettaient d'obtenir des résultats identiques quel que soit le laboratoire qui les appliquait, sachant que l'équipement matériel, les conditions de travail (hygrométrie, pression et température atmosphériques) et l'état des échantillons réceptionnés pouvaient varier énormément d'un laboratoire à l'autre.

— il a permis de comparer, pour chaque laboratoire, les résultats obtenus avec les méthodes ISO et ceux obtenus avec la méthode officielle du pays correspondant lorsque celle-ci était différente de la méthode ISO.

— il nous a permis de constater, en tant qu'organisateurs du circuit quelles ont été les qualités et les défauts de l'échantillonnage (division du lot en échantillons identiques) de l'empaquetage (utilisation de sachets étanches) et de la transmission postale aux divers laboratoires (délais et état des échantillons à la réception).

— l'analyse des résultats nous a permis d'envisager l'organisation d'un second circuit plus performant, et même, en cas de succès, d'un circuit annuel par exemple permettant de vérifier la bonne homogénéité des résultats d'analyse des laboratoires au cours des années.

III. Organisation du circuit

Les participants

Parmi les 19 pays participants ou observateurs pour le SR 1 du SP 18, dix ont exprimé le désir de participer à l'intercomparaison. Leur participation s'est déroulée dans les conditions suivantes (**) :

pays (1) (2) (4) : seules les méthodes de référence ISO ont été utilisées.

pays (3) (5) (9) (10) (11) : ces pays ont effectué les analyses selon les méthodes ISO et selon des méthodes nationales différentes des méthodes ISO.

pays (12) : résultats non parvenus à ce jour.

France : trois laboratoires ont effectué des analyses :

(6) le Service des Instruments de Mesure (méthodes ISO)

(7) l'INRA (méthodes ISO et méthodes de référence fondamentales ISO)

(8) l'ITCF (méthodes ISO).

Les échantillons analysés

Les analyses ont porté sur 5 espèces et un seul niveau d'humidité par espèce. Pour chaque espèce et chaque laboratoire participant, 5 échantillons identiques d'en-

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(*) INRA = Institut National de la Recherche Agronomique.
ITCF = Institut Technique des Céréales et Fourrages.
BIPEA = Bureau Interprofessionnel d'Etudes Analytiques.

(**) Note du BIML = Le rapport a été rendu anonyme, sauf pour la France, en remplaçant chaque pays par un nombre.

viron 150 g ont été préemballés par le BIPEA en sachets étanches (paroi intérieure métallisée) puis transmis aux destinataires par colis postal le 1er octobre 1980. Parmi les 5 sachets, 2 étaient destinés à l'analyse par les méthodes ISO, 2 à l'analyse par les éventuelles méthodes nationales, le dernier servant de recours en cas d'incident (erreur d'analyse ou sachet percé).

La présentation des résultats

Chaque participant a reçu, avec les échantillons d'analyse, une fiche réponse qui a permis de connaître les conditions d'essais de chacun des participants, à savoir :

date de réception des échantillons

date d'analyse

état des échantillons à la réception

qualités du matériel utilisé

particularités des méthodes de référence nationales lorsqu'elles étaient effectuées en plus des méthodes ISO.

L'ensemble des résultats et des informations recueillis nous ont conduit à l'analyse suivante.

IV. Analyse statistique des résultats de mesure - Méthode classique

Pour réaliser cette analyse nous nous sommes appuyés sur les techniques d'analyse et d'interprétation statistique des résultats d'un essai interlaboratoire décrites dans la norme française NF X 0604 et dans le projet de norme internationale ISO DIS 5725.

L'analyse a ainsi été menée suivant deux procédés différents :

1. Analyse des résultats par niveaux (c'est-à-dire par espèce de grains).
2. Analyse globale.

IV.1. Analyse des résultats par niveaux

	moyenne	$\sigma(r)$ écart type de répétabilité	$\sigma(R)$ écart type de reproductibilité
Maïs corné	12,05	0,035	0,19
Maïs denté	13,25	0,038	0,14
Orge	14,26	0,035	0,19
Farine	15,31	0,040	0,37
Blé tendre	16,09	0,039	0,31

IV.2. Analyse globale

Les résultats finaux, c'est-à-dire toutes espèces confondues, ont été :

$\sigma(r) = 0{,}039$

$$\sigma(R) = \sqrt{\hat{V}\ (R)} = \sqrt{\hat{V}(r) + \hat{V}(L\times M) + \hat{V}(L)}$$

avec $\hat{V}(r) = \sigma^2(r) = 0{,}0015$ variance de répétabilité

$\hat{V}(L \times M) = 0{,}0484$ variance d'interaction « laboratoire-niveau »

$\hat{V}(L) = 0{,}0292$ variance interlaboratoire

d'où $\sigma(R) = 0{,}28$

V. Comparaisons entre laboratoires - Test de cohérence et d'ajustement

Les résultats de l'analyse du point IV conduisent à comparer les laboratoires entre eux, notamment pour éliminer ceux dont les résultats sont non ajustés, c'est-à-dire s'écartent des résultats moyens d'une valeur telle qu'avec un haut niveau de probabilité on doit conclure qu'ils ne sont pas alignés avec l'ensemble du groupe ayant participé à l'expérience.

De même certains laboratoires peuvent, bien qu'alignés correctement, être aussi considérés comme non cohérents dans la mesure où la dispersion de leurs résultats est significativement trop élevée, comparée à celle des autres. C'est ainsi, que les laboratoires (10) et (11) ont dû être éliminés de cette analyse à cause de leur non alignement (ou ajustement) avec le groupe.

Afin de visualiser de façon très concrète les positions des laboratoires restants deux notions nouvelles ont été introduites :

δ l'écart d'ajustement

et C l'écart de cohérence

A chaque laboratoire peuvent être affectées une valeur de δ et une valeur de C :

δ caractérise l'écart moyen (c'est-à-dire tous niveaux confondus) du laboratoire considéré par rapport à la moyenne du groupe. C caractérise la dispersion des écarts de ce laboratoire correspondant à chacun des niveaux par rapport à la moyenne du groupe. Ce mode de comparaison nous a amené à réaliser le graphe n° 1 qui visualise pour chaque niveau l'écart de chacun des laboratoires par rapport à la moyenne du groupe et le graphe n° 2 (diagramme cible) qui situe les laboratoires entre eux.

VI. Interprétation des résultats

VI.1. Répétabilité

Les résultats du point IV.1. et du point IV.2. relatifs à l'écart type de répétabilité $\sigma(r)$ nous paraissent très satisfaisants (ils ne tiennent pas compte des résultats du laboratoire (10) pour maïs corné, orge et farine, qui ont été éliminés lors de l'analyse car jugés aberrants pour la répétabilité avec une probabilité de 99 % sur la base du test de COCHRAN) pour plusieurs raisons :

— ils permettent de conclure que, avec une probabilité de 95 %, si un laboratoire effectue deux fois l'analyse de l'eau sur un même échantillon, l'écart entre les deux résultats obtenus ne dépassera pas $t \times \sigma(r) \times \sqrt{2} = 0{,}11$ % eau.

— le facteur espèce ne semble jouer aucun rôle. En effet, $\sigma(r)$ varie entre 0,035 (maïs corné) et 0,040 (farine) ce qui représente un écart faible.

— la répétabilité telle qu'elle a été analysée dans ce rapport intègre deux paramètres :

1° la répétabilité intrinsèque du laboratoire, qui exprime l'aptitude de ce laboratoire à réitérer correctement l'analyse de l'eau de plusieurs sous-échantillons provenant d'un même lot. C'est ce paramètre que l'on voulait analyser en calculant $\sigma(r)$ car c'est à lui que s'adresse la règle prévue par l'ISO relative à l'écart maximal de 0,15 % eau autorisé entre les résultats de deux mesurages consécutifs effectués sur le même échantillon.

2° la répétabilité inter-paquets qui exprime la qualité de l'homogénéité du titre en eau entre les divers paquets contenant des échantillons provenant du même lot qui ont été livrés à chaque laboratoire pour chacune des espèces testées. Pour certains laboratoires (résultats aberrants du laboratoire (10) principalement) c'est ce deuxième paramètre qui est à l'origine d'une valeur excessive de $\sigma(r)$. Cet incident provient d'une mauvaise étanchéité ou d'une perte d'étanchéité (paquet percé ou déchiré) d'un ou de plusieurs paquets, dont l'effet a été d'autant plus néfaste que les délais de transmission postale ou les délais d'analyse ont été longs.

VI.2. **Reproductibilité**

Les résultats obtenus pour la reproductibilité nous paraissent moins satisfaisants. En effet :

— les résultats du point IV.1. et du point IV.2. relatifs à l'écart type de reproductibilité $\sigma(R)$ ne tiennent pas compte des résultats suivants qui ont été éliminés lors de l'analyse, car jugés aberrants pour la reproductibilité avec 99 % de probabilité sur la base du test de DIXON : laboratoire (10) pour le maïs denté, laboratoire (11) pour le maïs corné et le maïs denté. Malgré cette élimination, $\sigma(R)$ reste important.

— ces résultats permettent de conclure que, avec une probabilité de 95 %, si plusieurs laboratoires analysent des échantillons provenant d'un même lot, leurs résultats respectifs ne s'écartent pas de la moyenne des résultats de l'ensemble des laboratoires de plus de $t \times \sigma(R)$, soit :

0,56 % eau si on raisonne toutes espèces confondues

0,28 % eau pour le maïs denté

0,38 % eau pour le maïs corné ou l'orge

0,62 % eau pour le blé tendre

0,74 % eau pour la farine

Ces chiffres nous paraissent forts au moins pour le blé et la farine ; il faut en effet les comparer à l'erreur maximale tolérée en plus ou en moins prévue pour le contrôle des humidimètres dans le 4e avant-projet de Recommandation Internationale OIML, et qui est, pour un titre de 15 % eau :

0,85 % eau pour les céréales autres que le maïs en classe I

1,00 % eau pour les céréales autres que le maïs en classe II

1,00 % eau pour le maïs en classe I

1,15 % eau pour le maïs en classe II.

— le rapport $\frac{\sigma(R)}{\sigma(r)}$ est de même trop important (8 pour le blé tendre et 9 pour la farine). Il montre que la bonne qualité de la répétabilité n'apporte rien à la qualité des analyses car l'erreur de reproductibilité est trop forte. On pourrait raisonnablement s'attendre, lors d'un prochain circuit, à ne pas dépasser 5 pour la valeur de ce rapport.

— une comparaison des résultats de ce circuit avec ceux du circuit français organisé chaque mois par le BIPEA montre d'ailleurs une bonne concordance pour les deux maïs et pour l'orge et par contre une différence importante pour la farine et le blé tendre (le circuit international est respectivement 3,6 et 2,2 fois moins bon que le circuit national pour ces espèces, en terme d'écart type de reproductibilité). Cette comparaison nous a permis de mettre en cause des paramètres auxquels on ne pensait pas et qui ont influencé de façon très nette les résultats de $\sigma(R)$:

1° pour le blé tendre, le titre en eau était de l'ordre de 16 % eau. Dans cette zone, il y a un risque évident de perte d'eau de la moûture lors du broyage et avant la première pesée, ce qui a conduit nombre de laboratoires à effectuer à juste titre un préséchage de l'échantillon en grains entiers (contrairement aux termes de la norme ISO). Cette méthode n'ayant pas été appliquée par tous les laboratoires [(2), (10) et (11) qui ont par conséquent obtenu des résultats plus faibles], $\sigma(R)$ s'en est trouvé augmenté.

2° pour la farine, il semble que la granulométrie fine de ce produit soit à l'origine des sous-dosages de plusieurs laboratoires [(4), (2), (11) et (10)]. En effet, une mauvaise étanchéité des paquets ou une perte d'étanchéité des paquets au cours du transport, ou encore une attente trop longue avant l'exécution des analyses ont pu diminuer le titre en eau des échantillons analysés alors que les mêmes phénomènes n'ont pas eu d'influence sensible sur les espèces en grains entiers.

INTERCOMPARAISON METHODE ISO - METHODE PAYS

N° Labos		Maïs corné		Maïs denté		Orge		Farine		Blé tendre	
		moyenne	*s*	moyenne	*s*	moyenne	*s*	moyenne	*s*	moyenne	*s*
(3)	*x*					**0,14**		**0,14**		**0,21**	
						14,53	0,02	15,63	0,03	16,47	0,02
	y					**0,27**		**0,32**		**0,38**	
						1 h à 130 °C préséchage 20 °C 10 à 20 h		1 h à 130 °C préséchage 20 °C 10 à 20 h		1 h à 130 °C préséchage 20 °C 10 à 20 h	
(5)	*x*	**0,00**		— **0,06**		— **0,09**		**0,03**		**0,14**	
		11,84	0,05	13,08	0,03	14,06	0,05	15,35	0,06	16,11	0,03
	y	— **0,21**		**0,17**		— **0,20**		**0,04**		**0,02**	
		2 h à 130 °C préséchage év. 10 mn à 130 °C		2 h à 130 °C préséchage év. 10 mn à 130 °C		1 h à 130 °C préséchage év. 10 mn à 130 °C		1 h à 130 °C préséchage év. 10 mn à 130 °C		1 h à 130 °C préséchage év. 10 mn à 130 °C	
(7)	*x*					**0,16**		**0,27**		**0,21**	
						14,40	0,05	15,72	0,02	16,36	0,09
	y					**0,14**		**0,41**		**0,27**	
						méthode fondamentale ISO		méthode fondamentale ISO		méthode fondamentale ISO	
(9)	*x*					**0,12**		**0,33**		**0,21**	
						14,33	0,04	15,61	0,02	16,25	0,06
	y					**0,07**		**0,30**		**0,16**	
						2 h à 130 °C		1 h 30 à 130 °C préséchage 10 mn à 130 °C		2 h à 130 °C préséchage 10 mn à 130 °C	
(10)	*x*	— **1,05**		— **0,82**		— **0,67**		— **0,18**		— **0,47**	
		10,43	0,18	11,89	0,09	13,29	0,02	15,05	0,39	15,19	0,06
	y	— **1,62**		— **1,36**		— **0,97**		— **0,26**		— **0,90**	
		1 h à 130 °C		1 h à 130 °C		1 h à 130 °C		1 h à 130 °C		1 h à 130 °C	
(11)	*x*	— **2,53**		— **1,96**		— **0,17**		— **0,22**		— **0,41**	
		12,22		13,44		14,57		15,38		16,49	
	y	**0,17**		**0,19**		**0,31**		**0,07**		**0,40**	
		1 h 30 à 130 °C préséchage 40 mn à 105 °C		1 h 30 à 130 °C préséchage 40 mn à 105 °C		1 h à 130 °C préséchage 30 mn à 105 °C		1 h à 130 °C préséchage 30 mn à 105 °C		1 h à 130 °C préséchage 30 mn à 105 °C	
ISO		12,05	0,03	13,25	0,04	14,26	0,03	15,31	0,04	16,09	0,04

x : écart (méthode ISO par le labo. - méthode ISO moyenne tous labo.)

y : écart (méthode nationale labo. - méthode ISO moyenne tous labo.)

VII. Intercomparaison des diverses méthodes de référence

Le tableau suivant récapitule les résultats obtenus par chacun des laboratoires ayant utilisé une méthode de référence autre que celle normalisée par l'ISO. Il permet de tirer certaines conclusions :

LABORATOIRES	RESULTATS															date de réception date d'analyse	
	groupe 1						groupe 2										
	Niveau 1 Maïs corné			Niveau 2 Maïs denté			Niveau 3 Orge			Niveau 4 Farine			Niveau 5 Blé tendre				
	x_{ijk}	moyenne	écart -type x 10^3	x_{ijk}	moyenne	écart -type x 10^3	x_{ijk}	moyenne	écart -type x 10^3	x_{ijk}	moyenne	écart -type x 10^3	x_{ijk}	moyenne	écart -type x 10^3	I	II
(1)	12,00 12,08 12,01 11,98	12,02	43	13,04 13,07 13,16 13,18	13,11	68	13,92 13,88 13,81 13,81	13,86	54	15,57 15,61 15,58 15,44	15,55	75	16,02 15,88 15,97 16,01	15,97	64	16.10.80 22.10.80	16.10.80 22.10.80
(2)	12,21 12,18 12,18 12,15	12,18	24	13,34 13,34 13,35 13,36	13,35	10	14,46 14,44 14,40 14,39	14,42	33	14,74 14,74 14,79 14,76	14,76	24	15,65 15,64 15,62 15,62	15,63	15	4.11.80 28.11.80	7.10.80 4.11.80
(3)	11,96 11,93 12,04 11,99	11,98	47	13,30 13,34 13,28 13,30	13,31	25	14,39 14,42 14,40 14,39	14,40	14	15,44 15,46 15,44 14,47	15,45	15	16,32 16,32 16,31 16,26	16,30	29	22.10.80 11.80	22.10.80 11.80
(4)	11,66 11,60 11,61 11,63	11,63	26	12,97 13,00 12,95 13,02	12,99	31	14,15 14,20 14,10 14,21	14,17	51	14,58 14,60 14,59 14,67	14,61	41	16,29 16,32 16,38 16,34	16,31	28	5.11.80 11 21. 11.80	14.10.80 29.10 et 05.11.80
(5)	12,10 12,10 12,00 12,00	12,05	58	13,20 13,20 13,20 13,15	13,19	25	14,20 14,20 14,25 14,25	14,23	29	15,40 15,40 15,30 15,25	15,34	75	16,25 16,25 16,20 16,20	16,23	29	10.10.80 6.11.80	10.10.80 30.10.80
(6)	12,11 12,11 12,12 12,13	12,12	10	13,38 13,35 13,29 13,31	13,33	40	14,30 14,31 14,32 14,32	14,31	10	15,52 15,52 15,50 15,50	15,51	12	16,31 16,28 16,36 16,34	16,32	35	10.10.80 29.10.80	7.10.80 29.10.80
(7)	12,12 12,14 12,12 12,14	12,13	30	13,42 13,41 13,31 13,34	13,37	54	14,42 14,42 14,44 14,41	14,42	30	15,60 15,60 15,57 15,56	15,58	21	16,35 16,21 16,29 16,34	16,30	64	8.10.80 9.10.80	6.10.80 7.10.80
(8)	12,24 12,26 12,24 12,23	12,24	13	13,38 13,36 13,35 13,36	13,36	13	14,36 14,38 14,43 14,42	14,40	33	15,61 15,59 15,59 15,59	15,60	10	16,35 16,37 16,38 16,38	16,37	14	2.10.80 9.10.80	2.10.80 8.10.80
(9)	12,24 12,30 12,29 12,25	12,27 [[12,29]]	29	13,35 13,37 13,40 13,43	13,39 [[13,50]]	35	14,35 14,38 14,38 14,41	14,38 [[14,57]]	24	15,65 15,64 15,64 15,64	15,64	5	16,34 16,28 16,33 16,25	16,30	42	19.01.81 5 au 11. 03.81	9.10.80 15 au 24 10.80
(10)	10,80 10,79 11,21 11,20	11,00 [[11,78]]	237	12,30 12,44 12,51 12,49	12,43 [[12,99]]	95	13,42 13,46 13,75 13,75	13,59 [[14,33]]	180	14,81 14,78 15,45 15,46	15,13 [[15,06]]	381	15,67 15,61 15,59 15,61	15,62	35	01.11.80 19.12.80	1.11.80 1.12.80
(11)	[9,52]	[9,52] [[11,75]]	[ ]	[11,29]	[11,29] [[12,95]]	[ ]	[14,09]	[14,09]	[ ]	[15,09]	[15,09]	[ ]	[15,68]	[15,68]	[ ]	20.11.80 6.01.80	20.11.80 22.12.80
Moy. générale Moy. définitive		11,74 12,05			13,01 13,25			14,21 14,26			15,30 15,31			16,09 16,09			

[[x]] résultat estimé (cf analyse de variance)
[y] résultat non conforme à la fiche réponse

Nota : les résultats du laboratoire (9) qui ont été estimés ne correspondent pas à des points aberrants mais au fait que les résultats réels de ce laboratoire ont été reçus lorsque l'analyse était déjà terminée.

— les résultats du laboratoire (7) (INRA) utilisant la méthode de référence fondamentale ISO sont cohérents et ajustés avec ceux du même laboratoire utilisant les méthodes de référence pratiques ; ils sont par contre très supérieurs à la moyenne des laboratoires utilisant la méthode de référence pratique ISO, ce qui montre que la moyenne de tous les laboratoires qui a été utilisée comme référence pour l'analyse des résultats est biaisée vers le bas par rapport à la valeur vraie.

— les résultats des laboratoires (3), (5) et (9) sont aussi bons lorsque ces laboratoires emploient la méthode ISO ou leur méthode nationale.

— les résultats du laboratoire (10) mauvais lors de l'utilisation de la méthode ISO le sont encore plus (sous-dosage accentué) lors de l'utilisation de la méthode nationale. Le temps de séchage raccourci (de 2 h ou 4 h à 1 h) explique aisément cela.

— les résultats du laboratoire (11), mauvais lors de l'utilisation de la méthode ISO, sont au contraire excellents lors de l'utilisation de la méthode nationale. Le préséchage systématique imposé par cette méthode a sans doute évité les problèmes de broyage si le broyeur utilisé était peu étanche ou échauffait le grain.

VIII. **Conclusion**

Les résultats de ce circuit nous paraissent très encourageants ; ils pourront cependant être améliorés lors d'un prochain circuit international à condition de :

réunir, si possible, un nombre plus grand de participants, au moins 12, afin que les analyses de variance soient possibles.

peser, au centigramme, les échantillons avant transmission et après réception afin de vérifier la bonne étanchéité des sachets.

de la part des participants, analyser si possible les échantillons dès leur réception et remplir les fiches-réponses conformément aux indications.

analyser les résultats par rapport à un étalon fondamental (méthode de référence fondamentale effectuée par exemple par deux des laboratoires participants), plutôt que par rapport à la moyenne globale qui, cette fois-ci a été biaisée vers le bas par les nombreux échantillons analysés tardivement.

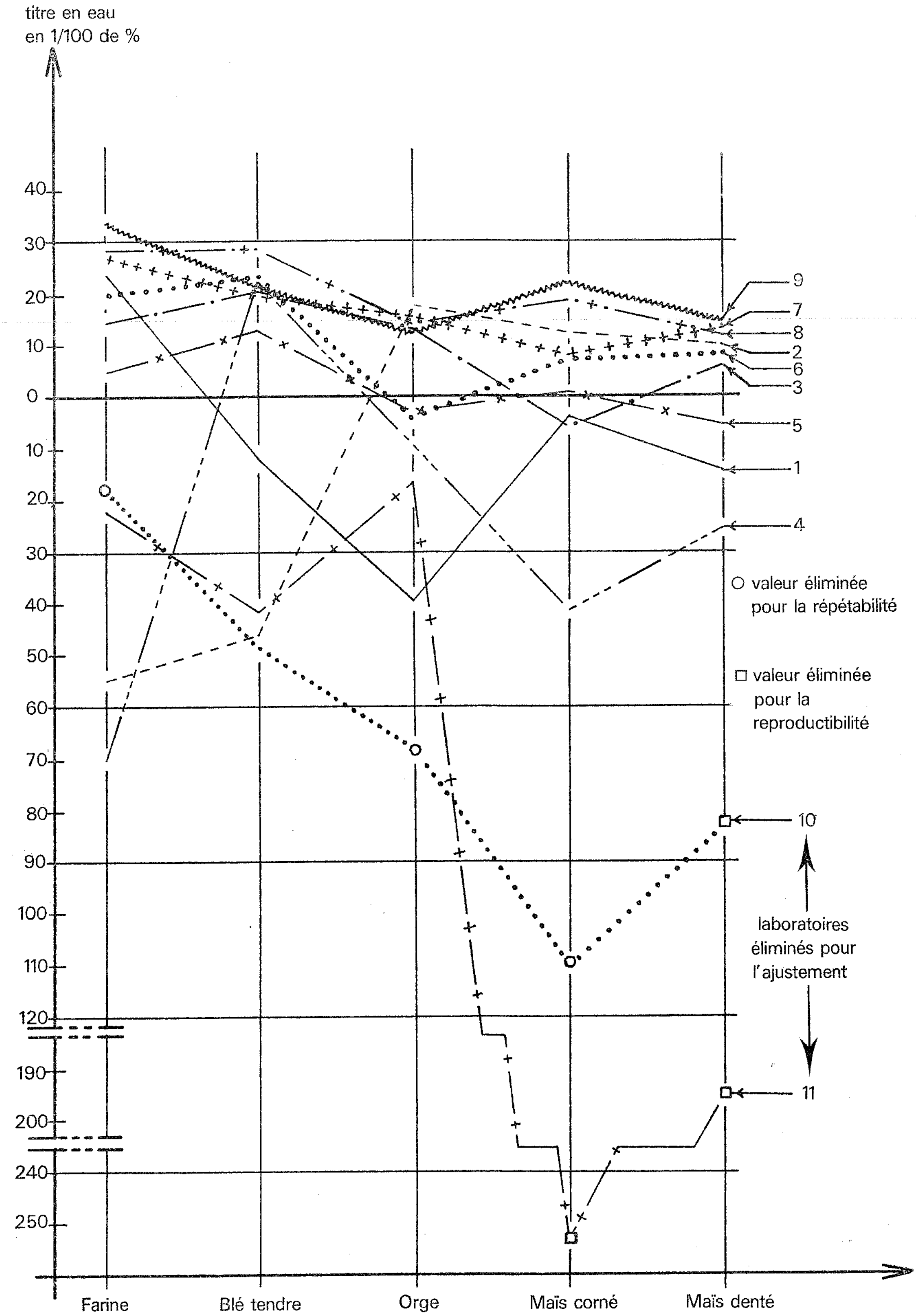
effectuer l'analyse pour plusieurs niveaux de titre en eau pour une même espèce afin de déterminer l'influence de l'utilisation de méthodes de référence différentes (sans préséchage en-dessous de 15 %, avec préséchage au-dessus) sur les valeurs des écarts type de répétabilité et de reproductibilité. Les résultats de ce premier circuit semblent montrer que l'écart type de répétabilité est fonction de la méthode utilisée mais pas du titre en eau — on peut ainsi s'attendre à un $\sigma(r)$ égal à 0,04 en-dessous de 15 % eau et un $\sigma(r)$ un peu supérieur mais constant pour toute la zone supérieure à 15 % eau — et que au contraire l'écart type de reproductibilité est fonction des deux paramètres, la méthode de référence utilisée et le titre en eau ; c'est pourquoi il sera possible de raisonner en terme de coefficient de variation plutôt que d'écart type pour la reproductibilité.

modifier, dans la norme ISO 712, le paragraphe 7.1.2.2. (Broyage avec conditionnement préalable) en ce qui concerne le niveau de teneur en eau au-dessus duquel le préséchage est nécessaire. Ce niveau doit manifestement être abaissé de 17 % à 15 %.

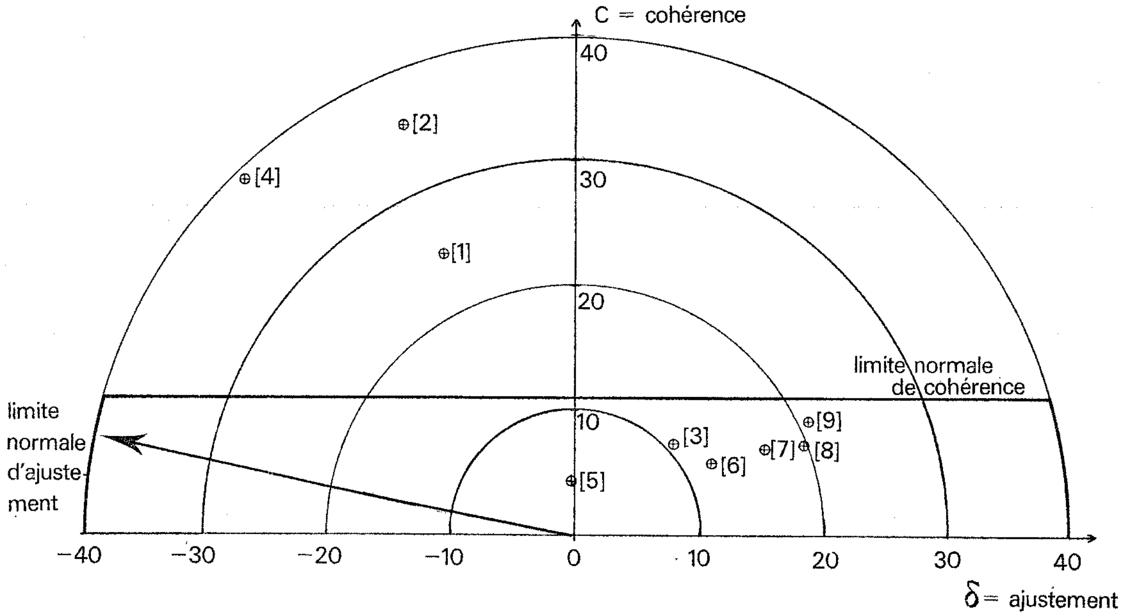
Il nous paraît donc très souhaitable d'organiser un second circuit d'analyse.

GRAPHIQUE N° 1

ECARTS DES LABORATOIRES PAR RAPPORT A LA MOYENNE, NIVEAU PAR NIVEAU



GRAPHIQUE N° 2



limite normale de cohérence : 11

limite normale d'ajustement : 40

DIAGRAMME CIBLE

AJUSTEMENT ET COHERENCE INTERNE DES LABORATOIRES

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ISO 6540-1980 : Maïs. Détermination de la teneur en eau.
Section I méthode de référence pratique.

NF X 06 041 (mars 1970) : Fidélité d'une méthode d'essai.
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Le PROJET du SYSTÈME de CERTIFICATION OIML

La certification de divers produits et services retient l'attention de plusieurs institutions internationales économiques, techniques ou commerciales.

Afin d'étudier les possibilités d'établissement d'un Système de Certfication OIML et d'estimer les avantages qu'un tel système pourrait présenter pour les utilisateurs et les fabricants d'instruments de mesurage, un groupe ad hoc a été institué par le Comité International de Métrologie Légale en 1978.

Le groupe a tenu trois réunions : en juin 1979, en mars 1980 et en mai 1981, avec la participation de représentants de la République Fédérale d'Allemagne, des Etats-Unis d'Amérique, de la France, de la Pologne, du Royaume-Uni et de la Tchécoslovaquie et du BIML.

En partant d'un document initial proposé par la République Fédérale d'Allemagne, des projets successifs, préparés par le Bureau, responsable du secrétariat du groupe ad hoc, ont été soumis à la discussion. Le dernier projet, préparé en 1981 et discuté à la troisième réunion (*) a reçu l'accord de principe des membres du groupe et a été adressé en octobre 1981 aux Membres du CIML, pour avis et observations.

Le Système de Certification OIML décrit dans ce projet vise à la délivrance de certificats attestant que les instruments de mesurage en question ont été trouvés conformes aux exigences de l'OIML lorsqu'ils ont été examinés selon les méthodes d'essais également spécifiées.

Afin de ne pas créer d'entraves dans l'échange international, le Système de Certification OIML pourra s'appliquer à tout instrument, qu'il soit fabriqué dans un pays-membre de l'OIML ou dans un autre pays.

La procédure de certification pourra être entamée à la demande des fabricants d'instruments de mesurage.

Les essais des instruments seront effectués sous la surveillance des Membres du CIML, qui, seuls, pourront décider de l'octroi, du refus ou de la révocation d'un certificat de conformité.

Un organe central, la Commission de Certification OIML, assumera la coordination de divers éléments du Système de Certification et son perfectionnement. Pour l'application pratique du système, la Commission établira des « Documents de Référence » basés sur les Recommandations et Documents Internationaux de l'OIML. Le Bureau se chargera du secrétariat de la Commission et tiendra registre des instruments auxquels des certificats de conformité ont été octroyés.

Au moins dans une étape initiale, la participation des Etats-Membres de l'OIML aux activités se référant au Système de Certification OIML dépendra de leur libre décision. Tout Etat pourra reconnaître ou ne pas reconnaître les résultats d'une certification effectuée dans le cadre de ce Système.

Le Système de Certification OIML aura pour but de fournir une information objective sur les caractéristiques d'instruments de mesurage, suivant les critères établis par l'OIML et fera avancer les travaux de l'Organisation en ce qui concerne :

(*) « Principes du Système de Certification OIML » — Projet (Document n° 6 A, BIML, juin 1981).

— l'harmonisation des exigences métrologiques qui sont imposées aux instruments de mesurage d'une même catégorie, fabriqués dans différents pays ;

— l'harmonisation des méthodes d'évaluation des performances métrologiques des instruments de mesurage ;

— la reconnaissance mutuelle des résultats du contrôle des instruments de mesurage effectué par les services métrologiques de divers pays.

En outre, le Système de Certification OIML sera susceptible d'exercer, par rétroaction, une influence favorable sur les Recommandations et Documents Internationaux qui en constitueront la base. L'application directe de ces Recommandations et Documents permettra en effet de déceler toute lacune, inconsistance ou ambiguïté de description ainsi qu'une éventuelle imperfection des spécifications dont certaines peuvent ne plus être justifiées et d'autres se montrer difficiles à appliquer dans les conditions pratiques d'essai.

Il est supposé que le Système, une fois formellement établi, ne pourra se développer que pas à pas, en fonction de la parution de Recommandations et Documents Internationaux suffisamment complets pour former des « Documents de Référence ».

Au début, le nombre de catégories d'instruments susceptibles d'être certifiés sera probablement très restreint. Parmi les premiers pourront se trouver, par exemple, les thermomètres médicaux, les compteurs d'eau ou d'électricité, pour lesquels il existe déjà des Recommandations précisant à la fois des exigences métrologiques et des méthodes d'essais et qui, dans de nombreux pays, sont déjà soumis au contrôle métrologique d'Etat.

Le Système de Certification se situe bien dans le cadre des objectifs de l'OIML, étant donné que :

1. son domaine d'intérêt est bien défini, cohérent et relativement restreint,

2. il permet de promouvoir des Recommandations Internationales définissant les performances et les méthodes d'évaluation des instruments de mesurage, objets de la certification,

3. la plupart de ses Etats-Membres ont la capacité technique pour examiner la conformité des instruments aux dites Recommandations, grâce aux laboratoires qui sont à la disposition de leurs Services Nationaux de Métrologie et dans lesquels les instruments sont déjà essayés suivant les prescriptions nationales.

4. les Recommandations Internationales de l'OIML ne diffèrent pas essentiellement des prescriptions nationales ; elles découlent en effet de règlements déjà existants et, une fois sanctionnées, elles sont appliquées par un nombre croissant d'Etats-Membres.

En métrologie légale, l'idée de certification est aussi ancienne que le contrôle des poids et mesures et a toujours compris les notions de définition des exigences, de constatation de conformité et d'impartialité de tout jugement. Le Système de Certification OIML, conçu comme une extension des systèmes nationaux, aura l'avantage d'hériter de leurs traditions et de bénéficier de leur potentiel actuel.

Z. REFEROWSKI

The OIML CERTIFICATION SYSTEM

The certification of various products and services claims the attention of many economic, technical or commercial international institutions.

In order to study the possibility of setting up an OIML Certification System and to estimate the advantages such a system may provide for the users and manufacturers of measuring instruments, an ad hoc group was set up by the International Committee of Legal Metrology in 1978.

The group held three meetings : June 1979, March 1980 and May 1981, with the participation of delegates from the Federal Republic of Germany, USA, France, Poland, United Kingdom, Czechoslovakia, and BIML.

Starting with an initial document proposed by the Federal Republic of Germany, the successive drafts, prepared by the Bureau which was responsible for the secretariat of the ad hoc group, were submitted for discussion. The last draft, prepared in 1981 and discussed during the third meeting (*), received an in principle agreement of the members of the group and was addressed in October 1981 to the Members of CIML, for their opinion and comment.

The OIML Certification System described in this article provides for certificates confirming that given measuring instruments were found to conform with the relevant OIML requirements when examined according to the test methods also specified.

In order not to create international trade barriers, the OIML Certification System may be applied to all instruments, whether manufactured in an OIML member country or in any other country.

The certification procedure may be initiated at the request of the manufacturers of measuring instruments.

The tests on the instruments will be carried out under the surveillance of CIML Members who, alone, may decide the granting, refusal or revocation of certificates of conformity.

A central body, the OIML Certification Commission will coordinate the various elements of the Certification System and its improvement. For the practical application of the system, the Commission will draw up « Reference Documents » based on OIML International Recommendations and Documents. The Bureau will be charged with the secretariat of the Commission and will keep a register of the instruments in respect of which certificates of conformity have been granted.

At least in the initial stage, the participation of OIML Member States in the activities concerning the OIML Certification System will depend on their own free choice. Every Member State may or may not accept the results of a certification carried out within this System.

The OIML Certification System will have as its aim to provide objective information on the characteristics of measuring instruments, following the criteria established by OIML and will further the work of the Organisation as far as :

(*) « Principles of the OIML Certification System » — Draft (Document n° 6 A, BIML, June 1981).

— the harmonization of metrological requirements which are in force for measuring instruments of the same category manufactured in different countries,

— the harmonization of the methods of evaluating the metrological performance of measuring instruments,

— mutual acceptance of the results of tests carried out on measuring instruments by the metrological services of different countries.

In addition, the OIML Certification System will be able to influence favourably, by feedback, the International Recommendations and Documents on which it is based. Direct application of these Recommendations and Documents will in fact reveal any gap, inconsistency or ambiguity of description as well as any possible imperfection in the specifications some of which may not be justified and others difficult to apply under practical conditions.

It is assumed that the System, once formally established, can only develop, step by step, with the publication of International Recommendations and Documents sufficiently complete to constitute the « Reference Documents ».

At the beginning, the number of categories of instruments suitable to be certified will probably be very limited. Among the first may be, for example, medical thermometers, water meters or electricity meters, for which Recommendations already exist specifying also the metrological requirements and the methods of testing and which, in many countries, are already subject to governmental metrological control.

The Certification System fits well within the range of OIML objectives, assuming that :

1. its field of interest is well defined, coherent and relatively restricted,
2. its helps to promote International Recommendations which define the performance and the methods of evaluation of the measuring instruments being certified,
3. most of its Member-States have technical capacity to examine the conformity of instruments with these Recommendations, owing to the laboratories which are available to the National Metrological Services and in which the instruments are already tested according to the national requirements,
4. the OIML International Recommendations do not differ essentially from the national requirements ; they derive in fact from the regulations already existing and, once adopted, are applied by an increasing number of Member States.

In legal metrology, the idea of certification is as ancient as the control of weights and measures and always included the notions of defining the requirements, of checking the conformity and of impartiality of judgement. The OIML Certification System, conceived as an extension of the national systems, should have the advantage of inheriting their traditions and of benefitting from their potential.

Z. REFEROWSKI

OIML SEMINAR

ELECTRONIC DEVICES INCORPORATED in WEIGHING and LIQUID and GAS METERING EQUIPMENT

Borås, Sweden, 21 to 25 September 1981

This first seminar organised by OIML was possible thanks to an invitation by Statens Provningsanstalt, the National Testing Institute of Sweden.

The subject chosen resulted from an inquiry made by BIML in 1979 about the feasibility of seminars and which showed that the problems arising for the legal metrology services in respect of the increased use of electronics should be given first priority.

The seminar was attended by more than 70 participants whereof 51 from 16 countries outside Sweden. Though participation was open to both electronic experts and to metrologists less familiar with modern electronics, it was found that the majority of the participants were specialists, however, not all in the same fields.

The industry concerned had been invited through their associations CECIP and CECOD to present their views and encourage discussions with legal metrologists.

The aim of the seminar was not to duplicate the work done by the reporting secretariats, but, BIML had found it appropriate to ask both SP 7-Sr 2 and the Commission of the European Economic Community to present the actual status of the drafts concerning electronic devices for measuring instruments.

The corresponding member countries had also been invited but only Albania was able to send participants.

Papers presented

I — First part, general problems

The first part of the seminar was intended to brief the participants on general aspects such as environmental effects, principles of construction, microprocessor and programming problems.

I-1 — F.X. Ries, National Bureau of Standards (USA), explained to the participants the foundations of electromagnetic interference (EMI), the problems encountered in measurement of such interference and in testing devices for electromagnetic interference susceptibility.

I-2 — O. Björklund, Alfa-Laval Company, Sweden, treated the general aspects of reliability of electronic devices from the industry point of view including life cycle cost and fault risk analysis and referred to work actually being carried out by IEC TC 56 concerning equipment reliability testing (IEC publication 605). He stressed the importance of the establishment of standardized reports concerning maintenance or operation disturbances as a feed-back link to the manufacturer.

I-3 — K. Spång, IFM Akustikbyrån, Sweden, who had been consultant to Statens provningsanstalt in the field of environmental testing of fluid meters and weighing machines, explained the general organisation of environmental testing with particular reference to the classification of environmental conditions, a work which is presently advancing within IEC TC 75.

I-4 — K. Horn, Technical University of Braunschweig, Fed. Rep. of Germany, gave a review of various types of mass and force transducers with electrical output.

I-5 — K.M. Lang, Mettler, Switzerland, continued the subject of the previous speaker by treating in more detail transducers using electromagnetic force compensation including problems related to the ageing of the magnets used and their temperature dependance, which has to be compensated by appropriate circuitry.

I-6 — P. Fahlen, Statens provningsanstalt, Sweden, explained with a great number of illustrations the principles of operation and data processing in the case of three types of flow transducers supplying an electrical output : electromagnetic, vortex and turbine flow meters.

I-7 — W.E. Vannah, Foxboro Company, USA completed the previous lecture by giving the views of the industry on measurement reproducibility and signal transmission in the case of electromagnetic and vortex flowmeters.

I-8 — L. Eriksson, Autotank, Sweden, described the use of computer systems for gasoline distribution pumps and stressed that new technology calls for a new philosophy in the pattern approval procedure. As an example of the complexity of systems he mentioned the fact that expanded functions may make use of different prices at different hours of the day, special prices for post payment systems, etc. If such systems should be totally pattern approved they would require computer aided tests and a great amount of documentation. He emphasized that pattern approval should take advantage of the possibilities of selfchecks between the meter and the primary display which are possible in a software controlled system.

I-9 — K. Gustafsson, Bofors Elektronik, Sweden, showed a microprocessor controlled balance which had intentionally been programmed so that false results could be obtained simply by operating the key board in a certain manner. He also stressed the very high accuracy and time stability required for resistors used in certain designs of load cell circuitry. A demonstration was also given of the use of a microprocessor controlled voice announcement system which may in the near future equip many measuring instruments in particular for giving instructions, announcing malfunctions, needs for adjustment or recalibration, etc.

I-10 — F. Katterheinrich, Hobart Corporation, USA, treated the subject of integrity of microprocessor-based weighing machines from the US manufacturing industry's point of view. Most of the states in USA have no prototype examination, only 12 states require a submission. The reference document is in all cases the NBS Handbook 44. A simplification and improvement has been introduced 12 years ago by the prototype examination programme of NBS. The NBS Report of Examination is not an approval but shows to what extent the equipment meets the requirements of Handbook 44. The US requirements stress some areas of external design such as marking requirements, anti-fraud in manipulation of controls, good display, etc. but do not enter into the internal design such as circuitry. Generally the author sees US regulatory efforts more oriented towards performance (tolerances) and anti-fraud than on reliability and design. There are strong indications that the consumer is not typically frauded by the instruments but by the manner in which goods are measured and sold.

The reliability of microprocessors has greatly improved, they have, usually built-in checking facilities and practical experience shows that a failure in a microprocessor creates a total failure. The author would not favour a quality assurance programme by government in the factory ; he concluded that the prototype examination can only cover a small part of reliability and quality and appears necessary in so far as to keep « honest people honest ».

II — Second part

The second part of the seminar was devoted to the impact of regulations including economical aspects and to pattern approval and practical verification. The first three speakers expressed the views of the industry on these matters.

II-1 — G.F. Hodsman, Avery Company, U.K., who is the president of the European weighing machine manufacturers association (CECIP) outlined the three main aspects of weighing machine regulations : pattern approval, initial verification, in-service examination and the problems created by new electronic technology. He suggested that special equipment made in small numbers should be subject to a simplified formal pattern approval, the initial verification being the essential legal step. The pattern approval of series-made weighing equipment incorporating computing devices usually requires that the examiner has access to the soft-ware programme listing which nowadays tends to be the most expensive component in design and very much subject to company security. If the manufacturer's equipment can be at least mentally segregated into a series units, it should be possible for the metrologist to check the functional requirements of the legislation without becoming involved in the design of the unit. This puts forward a requirement for suitable signal isolation between units but seems to be a realistic approach.

Another suggestion that pattern examination should be replaced by a system of manufacturer assessment is not favoured by CECIP. The problems of harmonisation and interpretation of rules are already such that at least within the European Common Market a single authority granting approvals would present advantages for all the parties concerned.

II-2 — J.H. Page, Herbert and Sons Ltd, U.K., treated the aspects which affect the manufacturer's development of electronic retail scales taking into account the commodity of use for the vendor and consumer's protection. Because of competition, factors such as speed of response and computation, immunity to external shock, vibration and to electrical interference have also to be considered to an extent which may sometimes go further than the legal requirements. The use of microprocessors has reduced the number of descrete components to less than 50 % of the number used prior to 1975 with the result of increased reliability.

The speaker finally stressed as of great importance to the manufacturer that changes in legal requirements are kept to a strict minimum since they may considerably affect the originally planned design and hence the real cost of the final product.

II-3 — G. Dittrich, Spanner-Pollux Company, Fed. Rep. of Germany, informed the participants about the use of electronics for water flow measurements. Electronic measuring devices such as electromagnetic induction meters are now currently becoming used for large diameters, 50 to 250 mm, followed to a lesser extent by turbine meters, whereas ultrasonic systems are being applied for still larger diameters. Of all water meters sold in the world, 90 % have a diameter of 25 mm or less, and are purely mechanical. They will most probably stay so for quite some time due to their low cost. Even in the case of heat meters the hydraulic part is mechanical. Domestic water meters may however to an increasing extent be equipped with data transfer systems. For such systems and for heat meters the interface between the measuring device and the observer will be a memory which can only be read with an electronic tool. Thus, such devices will have to be pattern approved and verified and the industry is looking forward for answers how this shall be done.

II-4 — J. Putzeys, Commission of the European Economic Community, informed the participants about the present status of the directives drafted within EEC concerning electronic devices. As regards weighing machines the future directive may possibly require that instruments to be used for sale to the public must be equipped with function checking devices.

II-5 — O. Warnlof, NBS, and R.S. Cohn, Acurex-Icore Co, USA, explained the present situation of the OIML SP 7-Sr 2 preliminary draft on electronic weighing machines as a result of recent deliberations within the US national working group. Some of the tests are similar to those of the EEC, but the use or not of checking devices is in all cases left to the decision of the manufacturer. The new concept of dividing a weighing machine into several units such as transducer/data handling/display has been introduced.

II-6 — T.D. Roodbergen, Dienst van het IJkwezen, the Netherlands, treated the general problems of pattern approval and verification of modern measuring instruments. He emphasized the fact that such equipment offers great flexibility through use of multiple functions and a number of options. For the metrology service it is not feasable to get into the details of the particular electronic units which in most cases have to be considered as « black boxes ».

As regards data systems he asked : How far shall legal control go ? Shall it include only the measuring sequence from the transducer to the first display or shall it comprise the whole system, or shall it stop somewhere in between ?

These problems are complicated by the fact that the original prototype may undergo modifications by the use of new components during manufacture. Furthermore computer systems are composed of units originating from different manufacturers. This « instability » of the prototype must be taken into account in the pattern approval procedure which should be sufficiently flexible to follow the developments.

As regards the influence on regulations it is apparent that a similar approach to that used for mechanical equipment is not possible because of the great number of regulations required. Furthermore these would be out of date before they are finalized and may inhibit technical progress. Legal requirements should therefore not be based on design aspects. The regulations have to be of more general nature and reflect a shift of responsibility to manufacturer and user. In the opinion of the Dutch service the use of self checking or security protection devices would, if particularily specified in regulations, present an obstacle to technical developments and sometimes be unnecessarily costly. Mr Roodbergen stated that a better approach is to make general regulations and specify the test methods and the corresponding requirement values.

II-7 — A.J. Korenhoff, Dienst van het IJkwezen, described the practical testing and test facilities provided in the Netherlands. These include specially built facilities for climatic testing and for testing the susceptibility to electromagnetic interference.

It is hoped that continued test data will enable to establish whether the level of the requirements in the EEC draft directives are realistic. (During the subsequent discussions it was mentioned for instance that the immunity level value of 10 V/m for electromagnetic interference in the frequency range from 100 kHz to 500 MHz may have to be decreased to 3 V/m. Some participants questioned the usefulness of dry heat shock tests between only + 5 and + 40 °C in non-operating condition and the low number of only two cycles in the humid cycling tests).

II-8 — C.U. Volkmann, PTB, Fed. Rep. of Germany spoke about the two concepts of achieving metrological integrity for electronic devices : increased reliability and « operational fault perceptibility », the latter term being used in Germany for the use of checking devices, which signal errors in operation. PTB is very much in favour of checking devices, whether automatic or not. However, certain parts of some types of electronic instruments are difficult to be provided with checking devices such as for instance a strain gauge load cell and a combination of both methods may have to be used, whereby the load cells may be tested separately. (In the discussion which followed the problems of checking liquid crystal displays were raised, it was mentioned that the reliability of some makes of displays was now improved).

II-9 — P. Brandes in collaboration with M. Kochsiek, PTB explained how in a weighing machine equipped with a strain gauge load cell the « operational fault perceptibility » using checking devices can be achieved using the facilities of the incorporated microprocessor.

II - 10 — J.C. Lange, Det norske justervesen, exposed a different approach used in Norway for the testing of weighing machines incorporating electronics. This includes first a study of the machine and its documentation to establish the most significant tests to be done on the particular machine. Experience has shown that frequently the operational temperature tests are most critical, especially when the lower limit of mains supply voltage is used. The cooperation system with the other Scandinavian countries in the field of pattern approval was emphasized. A document concerning this system is being elaborated and will be translated into English.

II-11 — F. Rasey, National Weights and Measures Laboratory, U.K., explained how pattern examination and verification of electronic petrol dispensing equipment is presently carried out in the United Kingdom. From the constructional point of view petrol dispensing equipment must be provided with a number of interlocks to prevent faulty operation, they are however now to a large part built-into the software and become invisible. On the whole this leads to the fact that the bulk of verification work must be carried out as a performance test.

Susceptibility to electrical disturbances seems to remain the greatest disadvantage when comparing an electronic pump to the traditional mechanical pump. The immunity to such disturbances is generally good but experience has shown some extremes. High powered mobile Citizen Band radio transmitters are thus likely to create problems for a certain number of installations.

II-12 — D. Mencke, PTB, explained the method of carrying out pattern approval in the Federal Republic of Germany for fluid and gas meters equipped with electronic devices. The PTB requirements depend on the one hand of the type of connection or data transmission between subassemblies or complete units and on the other hand on the type of signal transmitted : amplitude, frequency, pulse interval, number of pulses or coded pulses. The author stated that even large systems may be approved within a short time by PTB in accordance with the approval requirements thus laid down.

II-13 — P. Koch, Federal Office of Metrology, Switzerland, presented his point of view on legal requirements on electronics in measuring instruments. He stated that for a legal metrology service it is difficult to undertake the full guarantee as regards an electronic product by reliability testing : it would take too long a time and be very costly. Such tests should be done by the manufacturer in his own interest.

Legal requirements can be based on two systems :

— one in which the Government does not ensure the metrological characteristics or quality but where the manufacturer or the user is held responsible, this may be classified as a repressive system

— one in which the Government does guarantee the metrological characteristics in which case checking or redundancy devices will have to be prescribed rather than reliability.

Conclusions

Due to the large number (23) of papers presented, the time for in-session discussions was sometimes too short especially in view of all the problems to be treated. We have above tried to reflect some of the main points of the questions raised by the speakers to which the seminar itself could not formulate any answers but which have to be further debated within the competent reporting secretariats or technical committees.

We are now trying to summarize in a few sentences the consensus of opinion and the main points made in speaches and discussions :

— the problems pertaining to the increased use of electronics are to a large extent common for many types of instruments ;

— the flexibility required to cope with rapid developments leads to the necessity for regulations of general character and not pertaining to particular constructions ;

— testing by the metrology services to ensure reliability is difficult, costly and should as regards certain tests not be done on a single specimen or prototype only ;
— the prescription of checking devices is possible in many cases, but it may not always be easy to cover some types of transducers (such as strain gauge load cells) ;
— the requirements to be laid down for operational environmental tests and in particular for immunity against electromagnetic interference have to be further studied in the light of more experimental data ;
— initial verification of electronic equipment as regards conformity with an approved pattern has become very difficult in particular as a number of functions are built-into the software ; this may lead to a higher degree of performance testing rather than checks of construction ;
— legal requirements may have to be laid down with increased shift of responsibility from the legal metrology authority to the manufacturer or the user ;
— reprogramming with no replacement of parts or breaking of seals but simply through external electrical signals is now possible for certain types of programme memories ;
— data liaison with remote places is becoming frequent ; metrology services may in some cases have to prescribe one-way transmission especially if price computation forms part of the legal control (which is not the case in a certain number of countries) ;
— the separation of the various units for individual approval or verification may call for a prescription to use special isolators (and may require a certain amount of standardization) ;
— cooperation with IEC may be required particularily on this last point as well as for the problems of electromagnetic interference and climatic testing.

Acknowledgements

The BIML and all the participants greatly appreciated the hospitality of Statens Provningsanstalt and the facilities provided for the seminar.

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S.A. THULIN

ETATS-UNIS d'AMERIQUE

The INFLUENCE of ELECTROMAGNETIC INTERFERENCE on ELECTRONIC DEVICES

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RESUME — L'exposé ci-dessous a été présenté lors du séminaire OIML sur l'électronique à Boras en septembre 1981. Son but est de donner aux agents des services de métrologie légale une idée des problèmes primaires que présentent la mesure des interférences électromagnétiques et l'influence de ces dernières sur le bon fonctionnement des instruments de mesure comportant des dispositifs électroniques. Le travail du National Bureau of Standards dans ce domaine est également brièvement décrit.

SUMMARY — This paper was presented at the OIML seminar « Electronic Devices incorporated in Weighing and Liquid and Gas Volume Measuring Instruments » which was held in Boras, Sweden, in September 1981.

Introduction

This paper is intended to give the legal metrology weights and measures community an elementary understanding of the electromagnetic interference (EMI) problem associated with electronic devices.

The approach followed here will be to first present a brief understanding of what electromagnetic (EM) waves are and the complexities involved in the understanding of their associated parameters. Following this is a discussion of the electromagnetic spectrum and its general pervasiveness and the effects changing technologies have had on electronic devices over the past forty years.

A brief outline of the different types of testing methods and facilities will be presented.

A description will be given of present National Bureau of Standards EMI programs to show how they differ from past approaches to EMI measurements.

The implications and ramifications of electromagnetic interference will be outlined. This includes reduction in productivity, questionable interchangeability and compatibility of component and system and possible negative effects on trade.

What is an EM Wave ?

An electromagnetic (EM) wave is defined by the Institute of Electrical and Electronic Engineers as, « A wave characterized by variation of electric and magnetic fields » [1]. An example of a simple electromagnetic wave is shown in figure 1. Here can be seen the two co-existing parts, an electric field denoted in the figure by the solid line and a magnetic field denoted by a dotted line ; they exist in two planes perpendicular to each other and perpendicular to the direction in which the wave is travelling denoted by the arrowhead on one end of the wave. The characteristics of the wave are embodied in the electric and magnetic fields. An electromagnetic wave is multidimensional and a very complex phenomenon.

The parameters associated with EM waves include 1) pattern, 2) spatial coordinates, 3) direction, 4) time, 5) frequency, 6) distance from radiating signals, 7) power (amplitude), 8) polarization, 9) waveform, 10) number of signals, and 11) interaction with local materials. The figure 2 is a representation of some of these parameters. The figure shows two cuts through the time, amplitude and frequency space. The figure shows that at a single frequency amplitude can vary with time whereas at a single instance in time amplitude can vary with frequency. The next three figures illustrate

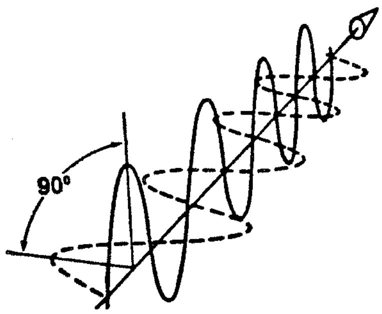

Figure 1
An artist's concept of an electromagnetic wave

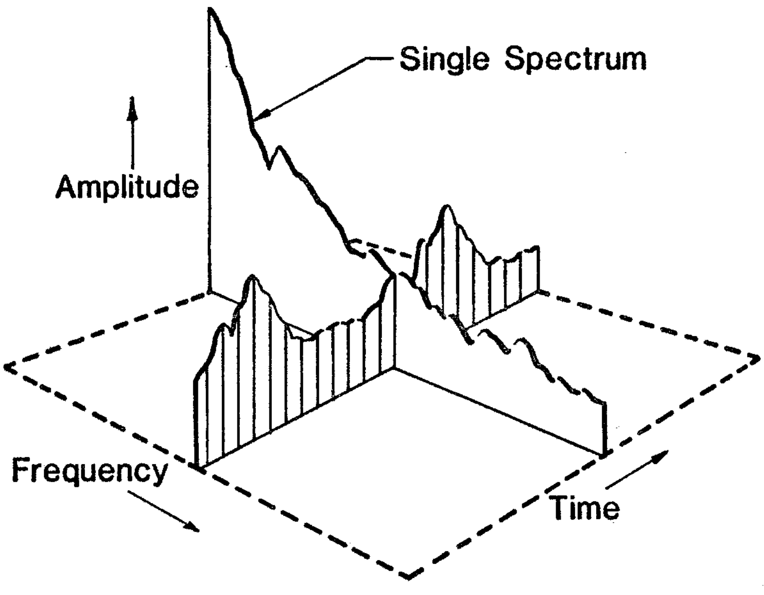

Figure 2
Plot of electromagnetic wave parameters as a function of frequency and time

the necessity for looking in all directions. Figure 3 shows the fields from mining equipment seen looking in one direction at one point in space ; the next two figures 4 and 5 show the other orthogonal directions [2]. Upon examination it becomes apparent that all directions must be known if the field at a point is to be understood. This demonstrates only the effect at one point in space and over a very short period of time.

It can also be shown that waves can be generated that travel along the same axis and are coherent but are degrees out of spatial phase with each other, this is called polarization. This phenomenon can result in erroneous measurements if the instrumentation used is sensitive to one phase.

Normally electromagnetic waves will become weaker as one gets further from the source but the amount of power that occurs at any point in space is dependent on the pattern of the radiation since the power in a wave might be distributed in all directions or may be in a very concentrated pencil beam.

The most commonly used parameter of the electromagnetic field is frequency. This refers to the number of oscillations per second the wave takes. Many signals of different frequencies may be combined to form one complex waveform. This type of wave may be referred to as a modulated wave.

The interaction of electromagnetic waves with materials may vary from absorption to reflection. This effect can change with variations in temperature, humidity, or combination of materials and the incidence angle at which the wave strikes.

The range of the spectrum of frequencies normally considered for electromagnetic waves is from below power line frequencies to daylight (10^{-2} Hz to 10^{22} Hz). The area normally considered for electromagnetic interference is from 10 Hz to 10^{12} Hz.

The frequency spectrum of a single wave may have many facets. Included in these are single or multiple frequencies, modulation, complex waveforms and intermodulations. Modulation is the variation of the amplitude, frequency or phase of a signal. This variation normally contains the information being transferred by the signal. When two or more signals come together they may generate other signals that have relationships to the original signals. This process is called intermodulation.

Other types of signals such as digital signals are referred to as pulse signals which refers to a signal that departs from a first normal state, attains a second normal state, and ultimately returns to the first normal state. This type of wave can be represented by a series of single frequency signals of varying amplitude and therefore covers a wide portion of the spectrum.

Normally it is assumed that if the source of radiation is at a far distance the signal must be weak. This can be a false assumption, since when electromagnetic waves strike conductive structures the wave may be reflected in such a manner as to combine with other reflected waves and therefore enhance the signal at any given point in space. This enhancement can be shown to be as high as one thousand to one times the original level.

Pervasiveness of Electromagnetic Signals

Electromagnetic (EM) sources can be divided up into three general categories 1) continuous with time, 2) intermittent and intentional, and 3) unintentional.

EM sources included under continuous sources are broadcast services which include amplitude modulation (AM), frequency modulation (FM), shortwave (SW), and satellite and terrestrial communication systems. Other continuous sources are navigational aids, intrusion systems, and power transmission lines.

Examples of the intermittent intentional sources of electromagnetic energy are mobile communications and radars (ship, trucks, automobiles, and aircraft), paging

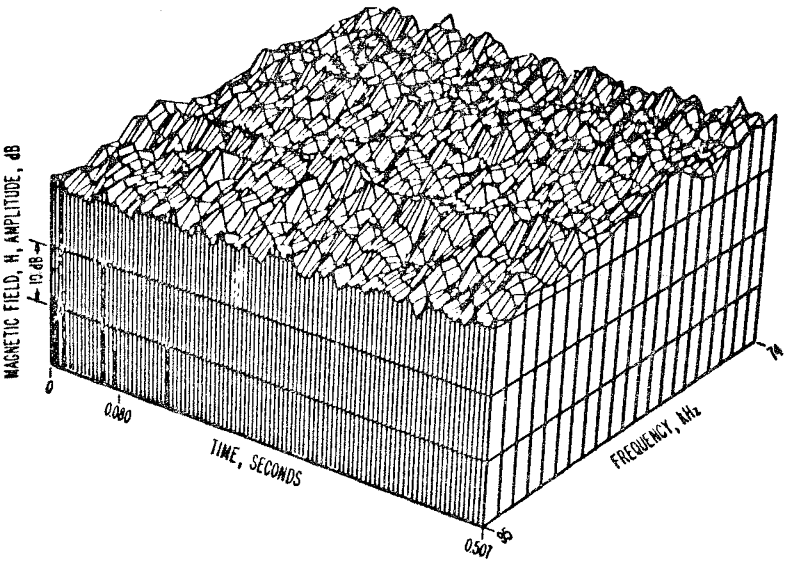

Figure 3
X component of electromagnetic wave

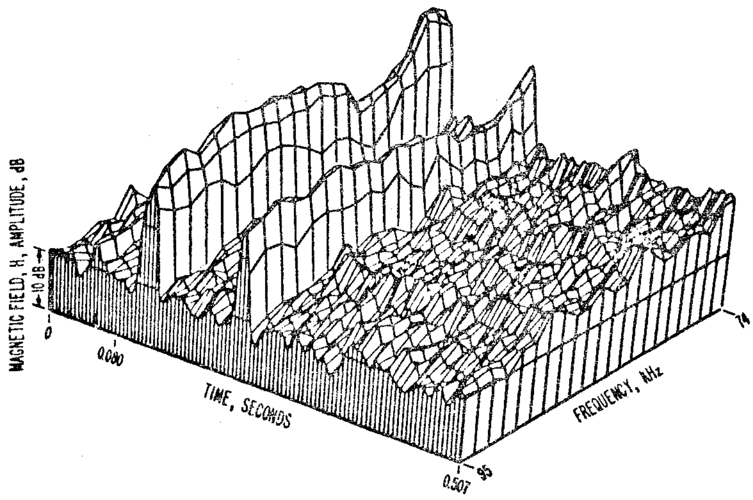

Figure 4
Y component of electromagnetic wave

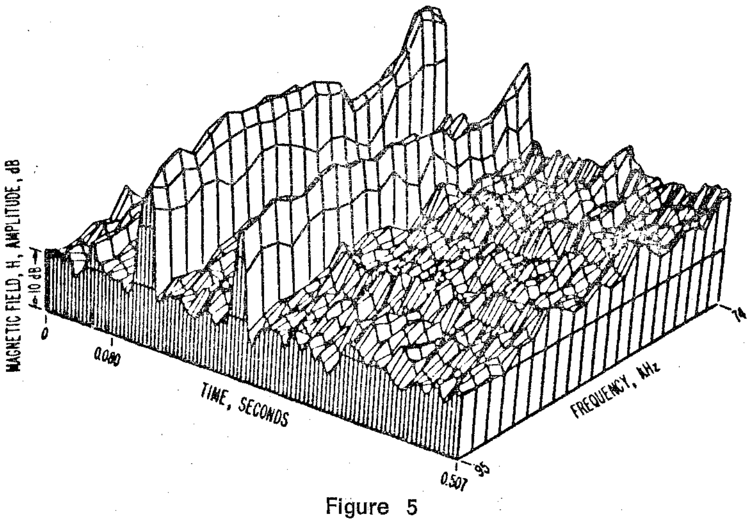

Figure 5
Z component of electromagnetic wave

systems and amateur communicators. The intermittent aspect comes from the fact that the sources move around or are not always in use. The intentional refers to the fact that they intend to radiate and are normally licensed.

The sources that do not radiate as their primary function are called unintentional and include radio frequency plastic sealers, industrial heaters, household microwave ovens, corona discharge from transmission lines or lightning, sparking action in electric motors and switches, automobile ignition, arc welding, computers and electronic control devices.

The numbers and variety of such devices and systems can be traced directly to the advent of the semiconductor technology. The change over the last forty years from vacuum tube electronics to highly complex semiconductor circuits has greatly enhanced the mobility (size/weight), power drain (battery operation), and cost (cheap consumer products) of electronic devices. This same change has also made the electromagnetic interference problem greater by producing products that are more susceptible to electromagnetic waves as well as greatly increasing the numbers and kinds of EM radiators.

The progress of the semiconductor industry is expected to remain fast. This has been demonstrated by the growth pattern in the industry from transistor to integrated circuits (IC's) to medium scale integration (MSI) to very large scale integration (VLSI) and now very high speed integrated circuits (VHSIC). These advances have caused the computer to become a much more powerful tool and have put it in the hand of almost everyone. The handheld calculator of today far exceeds the maxi-computer of the past. This has also added growth to the number of unintentional EMI sources and has increased the complexities of electronic devices in general.

Background Material Needed to Understand EMI Problems

Since electromagnetic waves are by their nature complex, it is difficult to understand the interaction of these waves with electronic devices. The degree to which an electronic device is interfered with is dependent on the complexity of the wave and the interaction phenomena encountered. As presented by Miller [3] a simple representation of the types of interactions is shown in figure 6.

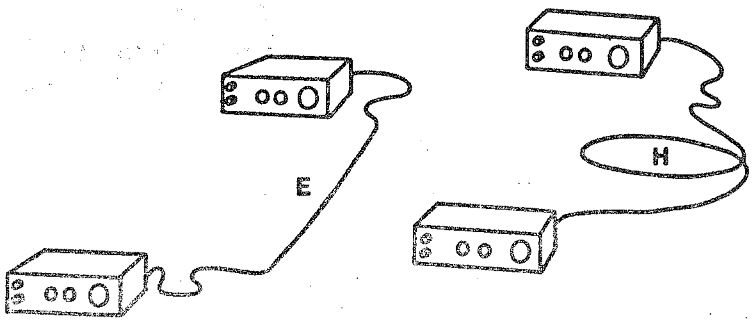

Figure 6
Two electronics packages connected by a wire or cable illustrating interception of electric and magnetic fields

If a straight piece of wire interceps the EM wave, it will pick up the varying electric field of the wave and induce a varying signal on the wire. The signal placed on the wire by this process will be superimposed on whatever signal the wire was already carrying. Figure 6 shows a straight section of wire connecting two boxes containing electronics where the wire is providing a channel of communication between the boxes. With the superimposed signal on the existing communicating signal, the original communicating signal is impaired resulting in a potential electronic malfunction.

Similarly, if a piece of wire forms a loop of some sort with appropriate dimensions to match it with the dimensions of the EM wave, it will intercept and pick up the magnetic field of the electromagnetic wave and in turn impose a varying signal on the wire, figure 6. This signal will also be superimposed on the signal being carried by the wire and in a similar way can cause the electronics to malfunction.

Electronics as used in most general applications have wire connections. Wires bring ac power to the electronics. Wires connect electronics to sensors for information input, to controlling systems, to other pieces of electronics, and to readout or display devices. In semiconductor devices, very small wires are used to make connections for ingoing and outgoing signals into the vital chips themselves. Computers are made of a collection of electronic packages properly connected together to function on demand, to perform their varied tasks. Even the electric power transmission lines themselves intercept electromagnetic waves which are superimposed on the ac power [3].

Electromagnetic waves are easily enhanced since they can be focused by metal objects such as walls, furniture, boxes on chassis, holes or slots in boxes. This is represented in figure 7 by the EM field entering into the building by way of the

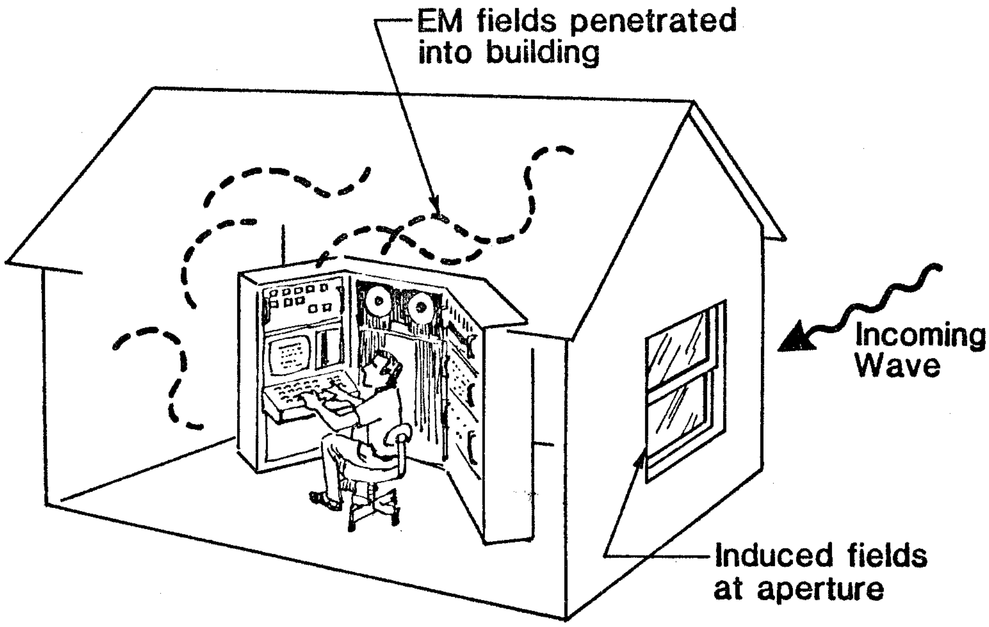

Figure 7

EM field building penetration

window. The field is reconstituted at the window and is re-radiated into the building bouncing off the walls and any object in the room, resulting in a field gradient being established that may be stronger at some points in the building than the field incident on the outside of the building [4]. This phenomenon can also be demonstrated inside a box such as a metal chassis or electronic device case.

Enhancement can also be demonstrated by examining a digital bit stream that may have large errors due to the addition and/or subtraction with time of conducted electromagnetic waves being picked up and combined with the normal signal being transmitted. These effects may also be nonlinear due to the detecting circuits in the electronic devices which are normally semiconductors.

The conglomeration of electromagnetic waves travelling in all directions comprises the EM environment. If we are to locate some electronics in a particular EM environment, we should design the electronics to coexist with the environment (if it is not too complex). We should first measure the environment and then design the electronics to function in a good facsimile of that environment. This is called making the electronics compatible. The problem that develops is that the EM environment varies in measurement complexity depending upon the distance away from the radiating sources. Further, the EM environment will vary with the radiating sources being turned on and off. In some locations, where the variations are significant, meaningfully measuring the EM environment is a monumental task. The radiated EM wave changes shape depending upon the distance from the source. Figure 8 indicates three

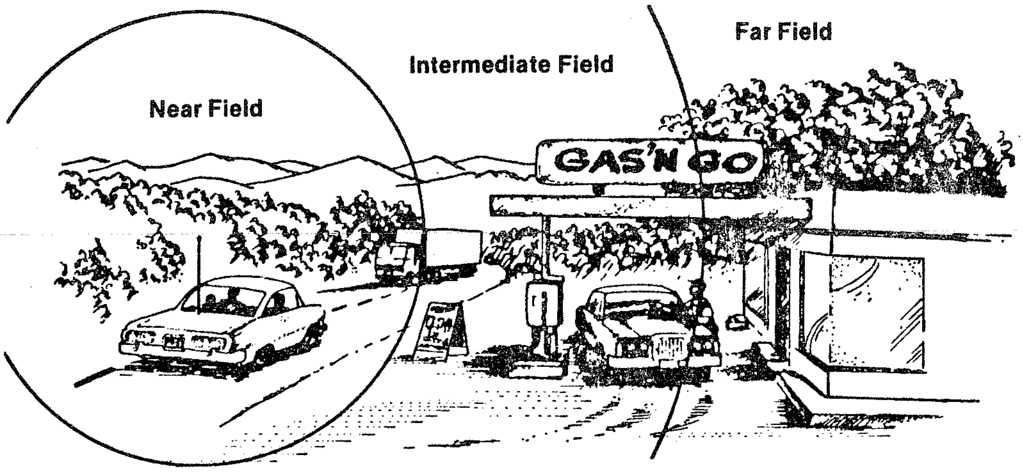

Figure 8

The zone of EM waves typically radiated from an antenna

zones. In the zone called the Far Field, the EM wave is far enough from the source that it has essentially become a plane ; that is the wave, if you could see it, would look like a sheet moving through space. This is why the shadow of a flying airplane at any altitude cast onto the earth is the same size as the airplane itself ; in this example, the light from the sun is a plane wave and as the airplane breaks the plane wave a shadow (or absence of light) is cast onto the ground. In the zone called the Intermediate Field, the EM wave is expanding as it moves away from the radiating source ; these EM waves are like ever-increasing spheres. You can see this expanding effect when you cast a finger or hand shadow on the wall of a room and your source of light is a candle flame ; the hand breaks the expanding EM wave of light and a large shadow is cast onto the wall. In the zone called the Near Field, the EM wave is not fully developed and the wave of figure 1 has not formed properly so it is very difficult to predict what is happening in this zone at a particular point.

EMI problems differ depending upon which of these three zones you are in from the radiating source. Of course you could easily be in the far field of one source and the near field of a second source. Usually we are exposed to a number of sources simultaneously. We only know how to measure the EM environment in the far field, and if we use equipment designed to measure in the far field in the other two zones we get erroneous results. If a number of objects exist in the path of the EM wave, the wave will bounce around as light does from light-colored objects and mirrors. This will disrupt the wave and artificially generate conditions similar to those encountered in the nearfield zone, which make it difficult to predict the energy at any particular point in space. The complications introduced by shadowing effects, reflecting effects, locating in various zones from the radiating sources, and other phenomena not discussed make contending with interference a difficult problem at best.

The phenomena associated with electromagnetic interference are so complex there has been very little theoretical work attempted. This has led to the practice of solving EMI problems from an empirical base only, which in turn has caused wide bounds to be put on the measures associated with EMI.

The National Bureau of Standards' goal is to develop, from a solid theoretical foundation, measurement techniques which include measurement procedures and instrumentation based on artifact standards as needed, for detecting, understanding and describing EMI phenomena. The realization of this goal is only made possible with the help of the computer in solving the complex analytical problems using numerical solutions.

The digital-diagnostic problem needs understanding if a solution to the EMI problem is to be effective in digital data communications. This problem is associated with the concept of bit-error-rate since a digital signal is a go-no-go electronic indication. If a bit bearing information in a data stream is interfered with no indication of error is apparent to the operator when random data are being transmitted such as numerical data.

The EMI Measurement Problem

One must first be able to characterize EM fields at a given point in space and time before there can be a full understanding of applying reference EM fields, characterizing a radiation source or recording of exposure history [5]. As was pointed out earlier the characterizing of an unknown field is an extremely complex problem and must be backed by a thorough theoretical understanding of the phenomena.

The solution to the EMI measurement problem lies in an approach that takes the individual problem into consideration. Presented here is a general guideline to follow in establishing the approach. The elements of the approach should include : 1) characterizing the operational environment, 2) quantifying the system's immunity, and 3) establishing a testing strategy.

First in characterizing the environment a physical survey of the local area for possible EM sources should be conducted and the types of signal that may be encountered identified. That is, are they continuous wave, pulsed, impulsive, what frequency and generally what levels of fields might be expected. The problem of whether the device of concern is in the near or far field of these sources must be ascertained. An estimate of the field in the operational environment can then be made from this information but with the present state-of-art this value is highly suspect. Therefore it is best to measure the environment. In order to do this the information gathered in the survey should be used to establish the qualifications and requirements of the necessary equipment that should be used to measure the signals. An experiment must be designed and data taken to record the EM environment data at the appropriate times of day and year to ascertain the worst case working day EM environment that could affect the workplace electronics performance and results.

With this information the specifications of the environment that the electronic device must operate in can be documented.

The next problem is to quantify the immunity of the electronic device under the environmental specifications. A test strategy should be determined such as testing the components, subassemblies, and/or the total electronic assemblies or systems.

There are many testing methods for electronic devices and systems available to both characterize the emission from electronic equipment as well as its immunity to EM waves. These techniques may include measurements in the open field with earth or with metal ground, the use of shielded enclosures, anechoic chambers, parallel plates, transverse electromagnetic (TEM) cells, Helmholtz coils, etc. ; all of which have their limitations in respect of frequency range, field uniformity, accuracy, availability and cost.

A comparison of twenty different measuring techniques showing the complexity of the problem has been made by M.L. Crawford [6]. Generally many of these techniques are not adequate for two reasons : 1) they are not sufficiently understood technically as regards interpretation of the results obtained and 2) not all EM measurement parameters can be assessed with them.

The final immunity test of any electronic device to the EM environment is a well planned verification of operation in the actual operational environment.

The electromagnetic interference problem first became significant during World War II ; however, due to the lack of a scientific understanding of the phenomena and a lack of tools, such as computers, needed to address the problem, only empirical solutions could be undertaken in developing testing methods, which lead very large error bounds in these methods. This situation necessitated the overdesign of EM hardening measures in critical applications to assure acceptable performance of electronic devices and equipment. With the advent of the transistor and the integrated circuit these large error bounds in testing were impossible to handle in design and performance testing ; therefore, a new emphasis on EMI measurements was started. In fact, the new semiconductor technology made available superior computer systems that offered us new capabilities with which to address these complex problems.

The National Bureau of Standards has begun an EMI program with the goal to develop a metrology base by which the EMI problem can be understood and attacked. The approach is analytical in nature and begins with the inception of an idea or concept which is then investigated for a sound theoretical foundation after which an experimental feasibility is established. If at this point the results are favorable a project is established by which practicability is demonstrated and the results disseminated.

The first challenge faced by NBS was to develop ways for characterizing localized EM environments. The problem addressed was to measure the leakage radiation from the household microwave oven. Since there was no instrument available to make this measurement several approaches were tried. The final design chosen had three orthogonal dipole antennas in an isotropic arrangement with diodes at the center of the dipole. This design resulted in a very complicated and expensive unit that was used in the initial microwave oven evaluations as well as in other bioeffects and environmental evaluations [7]. This instrument only measured the total E-field at a point in space. Further development of this work included an isotropic antenna system with a fiber optic link used to bring down not only amplitude but frequency information as well [8]. Both of these instruments were too expensive for industry to reproduce since the market at the time was very small. The frequency response of each of these devices was limited by the antenna response in as far as they had resonances and therefore more information about frequency components in the environment was needed than was normally available. Consequently an antenna that has no resonances was needed. NBS has since developed a new antenna that has a limited bandpass with no out of band resonances. It is presently being adapted to several environment measurement systems [9].

Further, a more reproducible broadband E-field meter was developed at NBS to measure field in the 0.2-1 000 MHz frequency range from 1-1 000 V/m [10]. An instrument based on this design is now being marketed commercially.

In order to evaluate these newly developed measurement instruments, NBS has developed techniques by which reference EM fields can be generated. These developments include the TEM cell [11], the spherical dipole radiator, anechoic chamber [12], ground screen facility [13], and standard loop calibration system [14]. Several of these systems are also useful for measuring electronic systems immunity.

NBS is in the early stages of developing techniques for characterizing sources of emission and reflectors or absorbers. This effort includes projects dealing with 1) field effect evaluation techniques such as the penetration of the ambient EM environment into buildings which is depicted in figure 7, 2) ways to quantify EM field enhancements effects and 3) measurement methods for evaluating integrated systems.

The future approaches to solving the EMI measurement problem seems to depend on the degree of theoretical understanding of the interference phenomena. Only recently have highly talented and competent theoreticians begun to work in this technical field but good progress is being made. With the clearer understanding of the phenomena will come effective solutions and testing methods.

Implications and Ramification of EMI

The implications and ramifications of electromagnetic interference lie in four general areas : 1) productivity, 2) interchangeability, 3) compatibility with environment, and 4) trade. Productivity will be affected where, due to interfering EM fields with electronic equipment, intermittent operation of production processes can cause production shutdowns. Some of the most susceptible devices to EM fields are digitally driven electromechanical systems. For example, NBS has tested digital tape drives and X-Y recorders and found them sensitive to fields below 1 V/m. This level of EM fields is often found around industrial sites. Another aspect of productivity is quality of product and this also can be affected if the production equipment operates in an unreliable manner due to subtle EMI effects.

Production can also be affected by the interchangeability of electronic equipment and devices. While interchangeability affords a convenience in maintenance or in upgrading performance if components or subassemblies are not EMI compatible with units they are intended to replace, the result is a reduced reliability and production level. The compatibility problem associated with EMI is so dependent upon the interface between equipment, that any change in component subassemblies or their connection can enhance the effect electromagnetic fields have on system operation. These effects may not be evident in the replaced part but rather in another component located at the point of enhancement.

The change of the electromagnetic environment with time can be greatly affected by changes in 1) weather, 2) structures in the vicinity, 3) vegetation, and 4) radiating EM sources. Weather can change the EM environment since rain or snow can change the conductivity of the ground and materials around the operational environment. This change in conductivity can change the pattern of the fields, possibly enhancing the fields at the point where the electronic device of concern is located. New or changing structures in the vicinity of the electronic device can have the same effect due to changing enhancements.

Since leaves on trees absorb EM waves the fields encountered may be different from one season to another. Therefore, if new vegetation is added or vegetation size increases with age or decreases with significant trimming, the environmental specifications will change from the initially established conditions and they in turn may need to be tracked during the life of the electronic device of concern.

New sources of EM energy are constantly being added to the environment. Changes in power level or location of old sources will also affect the environmental specifications. The operational system must either be shown to be immune to these variations of the EM environment or the EM environment must be tracked to correlate and correct for reflects of the environment on the electronic equipment of concern.

Due to these changing conditions it seems advisable that one incorporates, when possible, in situ verification of performance either by instituting a check procedure during operation that leads to confidence in the operational performance or by carefully planned preventive maintenance checks.

The effect on trade of electromagnetic interference may be a lacking of the ability to validate the precise quantification of trade commodities due to EM susceptibility of electronic measurement devices. Another obstacle to trade is non-uniformity of standard measurement practice. Measurement practices adopted for use in trade should be based on a sound technical basis and should be totally objective. Measurement practices also should be insensitive to site location or instrumentation. In order to do this properly a thorough set of definitions of terms must also be agreed upon.

Conclusions

The first part of an EMI problem is the characterization of the operational environment of interest which includes a survey of the local area for electromagnetic sources in order to choose the appropriate instrumentation and measurement methods. The specific types of signals must be identified such as continuous wave, pulse, impulsive, near-field, or far-field. After this is complete the environmental specifications can be established and the system immunity can be quantified.

The different types of testing methods and facilities include :

1) TEM cells, 2) screen rooms, 3) open-field sites, 4) reverberating chambers, 5) anechoic rooms, and 6) parallel plates .The testing strategy should go from testing components to subassemblies to systems and finally to in situ verification of operation.

Changes in the electromagnetic susceptibility of a device may take place due to the replacement of electronic components or subassemblies needed in the maintenance. The general environment is also of importance since electromagnetic waves can be altered by weather, structures in the vicinity (new or changed), new electromagnetic sources or a change in the local vegetation. Therefore a periodic in situ verification of electronic device performance may be necessary.

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The INFLUENCE of ELECTROMAGNETIC INTERFERENCE on WEIGHING MACHINES EQUIPPED with ELECTRONIC DEVICES

by **B. HENTE** and **E. SEILER**
Physikalisch- Technische Bundesanstalt
Braunschweig

RESUME — En complément à l'article précédent (*) nous donnons ci-dessous les résultats de quelques essais effectués en ce qui concerne l'influence d'interférences électromagnétiques sur des balances électroniques. Ces essais ont été conduits sur quatre balances de construction différente et de conception d'avant 1978. Ces essais montrent que des défauts de fonctionnement peuvent parfois se présenter, en particulier en ce qui concerne l'influence des émetteurs puissants de radiodiffusion ou communication mobile.

L'article est une traduction en anglais d'une parution dans PTB-Mitteilungen 88, Heft 6, Dezember 1978.

SUMMARY — As a complementary information to the previous paper (*) we are below indicating the results of some tests made as concerns the electromagnetic interference on electronic balances. These tests were made on four balances of different types of construction according to designs prior to 1978. The tests show that occasionally commercial instruments may be influenced in particular in the vicinity of strong fixed of mobile radio transmitters.

The paper is an English translation of a paper published in PTB-Mitteilungen 88, Heft 6, Dezember 1978.

1. Introduction

Nowadays, manufacturers' data on measuring instruments occasionally contain references such as « tested for normal operation with radiated interference ; radiates no interference », besides specifications on accuracy classes, drift behaviour, working ranges, etc. This is to demonstrate that on the one hand, the instruments are not susceptible to external electromagnetic interference, and on the other hand, that they themselves do not radiate interferences. It is important to be aware of this, as an increasing use of all types of electronic devices continually enlarges the problem of mutual electromagnetic interference (EMI).

The most spectacular examples showing the consequences EMI problems may lead to are the failures which have occurred in expensive rocket projects. But the effects of electronic devices which have not been proofed for normal operation with

(*) F.X. RIES and C.K.S. MILLER — The influence of electromagnetic interference on electronic devices. Bull. OIML No. 85.

radiated interference can also be felt in everyday situations, when for instance, the electronic gasoline injection system of a car engine stops functioning in the vicinity of a radio transmitter or when an electronic antilocking brake system is released by the radio of another car [1]. It is also conceivable that pacemakers are influenced by mobile transmitting stations or other sources of electromagnetic radiation.

Although these problems and their unpleasant consequences have already been known for some time, at present there are no generally binding regulations on the interference compatibility of electronic equipment, quite apart from those governing the military, aviation and space navigation. Even the above-mentioned specification « radiates no interference » in the example which became known to us was not established on the basis of measurements but derived from the fact that a portable radiotelephone with a power of 1 Watt at a frequency of 150 MHz and an antenna distance of 1.5 m did not influence the measuring instrument tested. The spectrum of possible sources of interference is, however, very broad. It comprises frequencies of several kHz (lightning discharges, inductive loops, spark discharges) up to many GHz (radar, satellite-communication).

For a comparison of various instruments with regard to their susceptibility to interference, field strength values must be indicated as a function of the frequency, and the measuring method applied must be specified. When elaborating a draft for an EEC directive on requirements for electronic devices for measuring instruments [2], such limiting values were therefore laid down.

Measuring instruments which are to be accepted for verification should not as a consequence of this interference, show any deviations which are greater than the maximum permissible errors on verification.

In order to get some idea of the requirements for protection against radiated interference, first the literature was checked for information on field strength values measured. Subsequently, four different weighing machines with electronic devices, which had already been accepted for verification by the PTB were submitted to the test program in accordance with the draft of the EEC directive. The results are described below ; here, emphasis is laid on such interference which takes effect via the electromagnetic field. Some of the results of tests with wire-borne interference are also mentioned.

2. Occurring field strengths

Maximum field strengths which have already been determined or which are still to be determined for immunity to interference have to be seen in comparison with field strengths occurring in operation. Representative data cannot be easily provided here, as a number of parameters must be taken into account : place, time, frequency and bandwidth. Instead of frequency and bandwidth, sometimes the time-dependence of the electric field vector would be more appropriate, but then the time and effort involved in specifications and tests would become too great.

Figure 1 shows spectra from various sources. Weak sources of interference were not included ; as regards other, possibly strong sources (e.g. switches, industrial plants), no numerical values have as yet been found. The amplitudes represented in Figure 1 for narrow band emissions can be easily compared with the susceptibility limits of the EEC draft also indicated and the military requirements [9]. The evaluation of the continuous spectra is problematical. A valid statement could only be deduced from it if a « bandwidth for susceptibility to interference » could be specified for the instruments in question. This is possible for instance for radio transmitters but not for electronic instruments in general.

When for test purposes a relative bandwidth — approximately 1 % of the nominal frequency — is introduced, the continuous spectra which are represented, to some extent lead to higher amplitudes in V/m than the narrow band emissions. The dominant

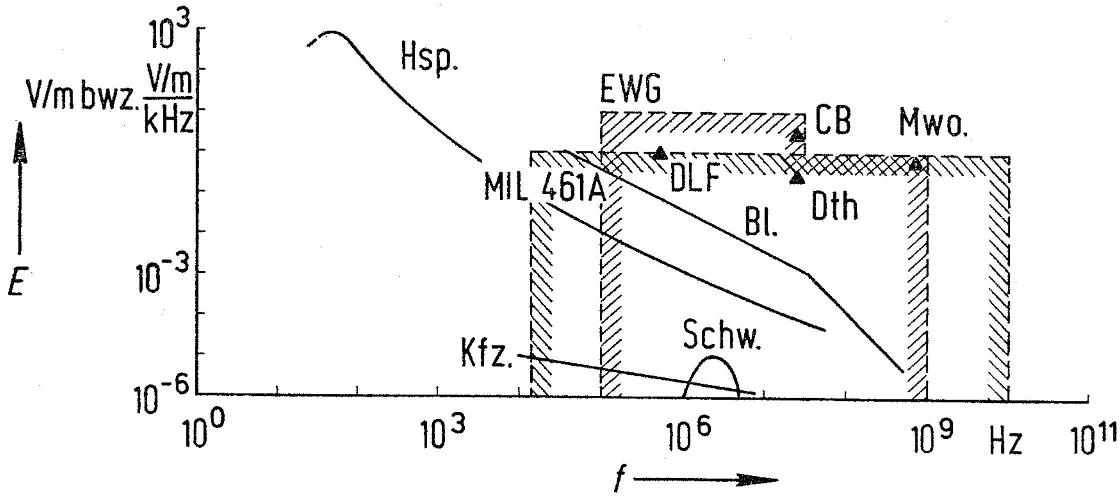

Figure 1

Examples of electric field spectra

Continuous lines represent broad band spectral densities, measured in V/ m per kHz ; triangles represent narrow band emissions, in V/m. The susceptibility limits of the EEC draft and those of MIL 461A are indicated also, in V/m.

Abbreviations :

Hsp : High voltage power lines, after [3]
Kfz : Automobile ignition, distance of 300 m, after [3]
Schw : Electric welders, distance of 300 m, after [3]
Bl : Lightning discharges, distance of 1.6 km, after [4]
DLF : Radio transmitter (Deutschlandfunk), distance of 10 km (Bittner, personal communication)
CB : CB-portable transmitter, distance of 2 m
Dth : Diathermy-unit, after [5]
Mwo : Microwave-oven, distance of 3 m, after [6]

interference sources are, however, mobile high-frequency instruments, apart from the immediate vicinity of high-voltage transmission lines and thunderstorms which are not considered here.

3. Weighing machines

For a preliminary survey of the weighing machines' reaction to electromagnetic interference, four weighing machines with different modes of operation were chosen and tested. The following table shows the functional principles.

Weighing machine	Transducer	A/D conversion	Display
1	Strain gauge	Digital voltmeter (dual slope)	7 segm. LED
2	Vibrating strings	Counter	7 segm. LED
3	Spring balance with code disk	Code converter	7 segm. LED
4	Magnetic force compensation	Pulse width modulation, counter	7 segm. LED

Three of the weighing machines were equipped with a price computer, calculating the retail price from a fed-in basic price and the weighing result.

It is obvious that the measurement results obtained for the interference compatibility of weighing machines cannot be representative of all other measuring instruments. As the measuring procedure can be repeated almost as often as desired within a short period of time and is almost continually repeated, strong but rare interference pulses are of no significance here whereas, e.g. in the case of a liquid meter, they might cause errors that cannot be corrected.

4. Tests in the electromagnetic field

The experimental set-up is represented schematically in Fig. 2. The test specimen and the antennas were positioned in a chamber screened by metal walls. The supply voltage available in the chamber had been filtered. The test field was generated in the frequency range from 10 kHz to 200 MHz by a frame antenna *, after its failure by a wire antenna terminating in a 50 Ω resistor. At higher frequencies of up to 1 GHz a horn antenna was used.

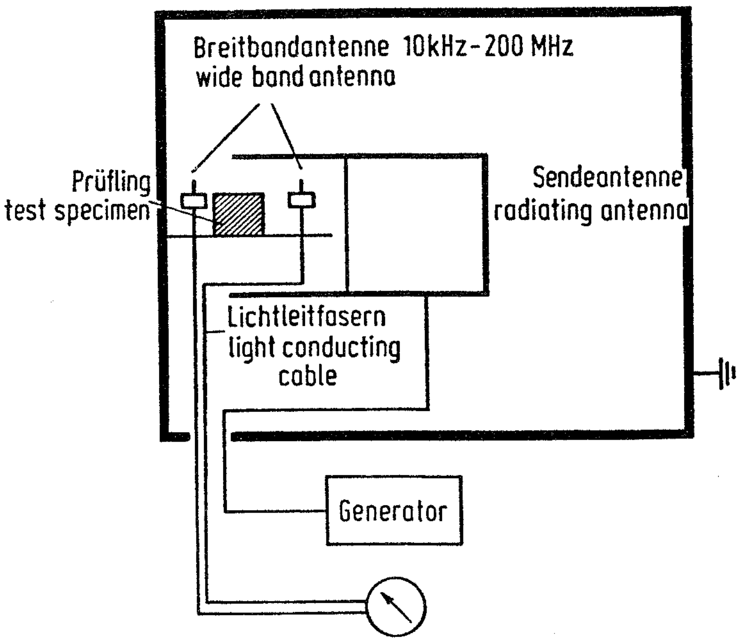

Figure 2

Experimental set-up for testing the immunity to radiated electromagnetic emissions

At frequencies of 200 to 1 000 MHz the measuring and transmitting antennas have been replaced by a horn and a conical antenna respectively.

The generator and the amplifier for the feeding of the antennas were placed outside the chamber. In the immediate vicinity of the test specimen, two small wide-band measuring antennas (frequency range 10 kHz - 200 MHz, height approximately 10 cm) were erected, the indication of which was transmitted outwards by means of ligth conducting cables so that a given field strength could be adjusted

(*) The term « frame antenna » refers rather to the outward appearance. Basically, however, the antenna concerned is a loaded transmission line, the geometric form of which produces the effect of a wide-band antenna.

externally. For frequencies > 20 MHz, they were replaced by a spiral-shaped conical antenna.

Prior to starting the test, the weighing machine was loaded, the basic price was fed in, where this was possible, and the weighing result was then awaited. The actual test took place in this stationary condition. A change in the weight or retail price indicated or an error indication were considered as a malfunction. In such a case, in order to determine the maximum field strength, the amplitude was lowered at constant frequency until the original indication again appeared.

In Fig. 3, the results for each of the four weighing machines have been represented as « susceptibility spectra ». First, tests were carried out with 10 V/m at the frequencies indicated by the upper lines. For each frequency at which a false weight display or a fault-signalizing reaction of the weighing machine occurred, the highest compatible interference amplitude was ascertained. Vertical heavy lines (in the case of a false weight display) or weak lines (in the case of a detected fault) characterize the amplitude range below 10 V/m in which interference occurred. Interference repeatedly occurred during variation of the frequency which afterwards when the amplitude was changed could no longer be detected. These points are marked on the 10 V lines.

In the case of the vibrating string scale, when the frame antenna was employed, false weight displays occurred in the frequency range from 10 to 20 kHz which includes the working frequency of the load cell. In the case of the wire antenna, this effect could not be repeated ; this behaviour can be explained by the presence of near field conditions (see below). Above 200 MHz, measurements were carried out at only three frequencies (300, 600 and 900 MHz) because of the more complicated level adjustment (other instruments, stronger frequency dependency). In the case of the interference detected here (weighing machines 1 and 2), the susceptibility to interference may be expected to extend over a wider frequency band. The remaining interference was limited to remarkably restricted frequency bands.

Various aspects of the test assembly are open to criticism. First of all, in each case the measurements were carried out in the near field of the transmitting antenna where the measurement of the electric field strength alone is not sufficient. In contrast to the distant field, the magnetic field is thus not determined. It must also be considered that the electric field adjusted already includes possible influence of the test specimen on the transmitting antenna.

An additional factor at the higher frequencies (200 - 1 000 MHz) is that here the wavelength is within the order of magnitude of the test specimen and that the formation of standing waves in the chamber has to be reckoned with. The erection of the measuring antenna next to or above the test specimen may then lead to false field strength values. The TEM transmission cell [7] would be an acceptable alternative making possible the simulation of far field conditions up to very high field strengths (500 V/m) without a screened chamber. Rather simplified, this is an expanded transmission line, terminating in the line impedance. A disadvantage of such cells, however, is that they can only be operated up to a certain limiting frequency, and the lower the frequency, the greater the cell. At a cross-section of approximately 1.5 × 1.2 m, the limiting frequency lies at 100 MHz.

Better test conditions for wavelengths below approximately 1 m can be created by lining the walls of the screened chamber with absorbing elements, e.g. pyramids covered with graphite, similar to an anechoic chamber. A few such rooms are already in operation see e.g. [8].

5. Conducted interference and electrostatic discharges

As regards conducted interference, the EEC draft only takes into account interference superimposed to the mains. Only some of the specified tests were carried out, one of them with the requirements limited. All the interference was applied on both conductors individually and in succession (asymmetrically).

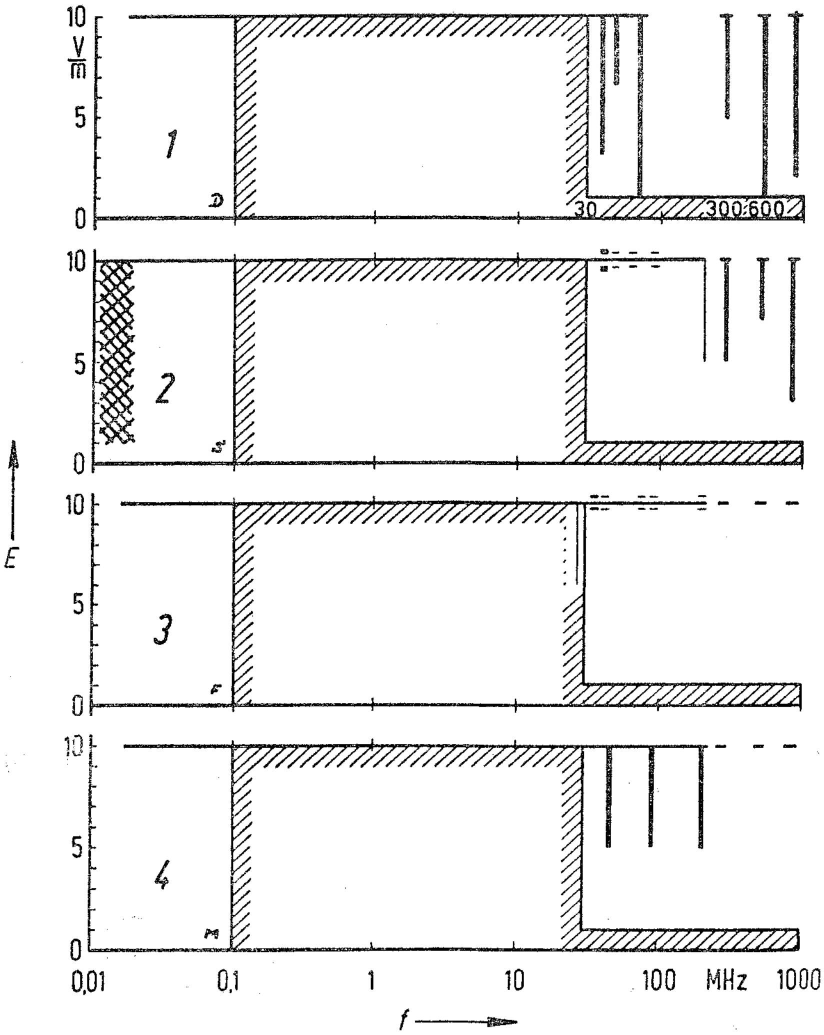

Figure 3

Results of susceptibility tests, radiated interference

The « susceptibility spectra » of the tested weighing machines are represented in the sequence given in the table of section 3. Simple hatching indicates the susceptibility limits of the EEC draft.

Cross-hatching (weighing machine 2) indicates interference created by a transmission line antenna only, not by a wire antenna generating the same electric field strength. The heavy line at 10 V/m indicates frequency and amplitude of the test field.

Vertical heavy lines : false weight display.

Vertical weak lines : detected faults.

Sine wave interference :

The requirements specify 5 % of the mains voltage for 30 kHz up to 150 kHz (in our case 11 V), 1 V for 150 kHz to 400 MHz. Up to 150 kHz, the interference is realized inductively via an isolating transformer ; from 150 kHz, capacitive coupling is used.

With one exception — weighing machine No. 4 — all weighing machines passed this test. The results for this weighing machine are represented, similar to those of the radiated interference, in Fig. 4.

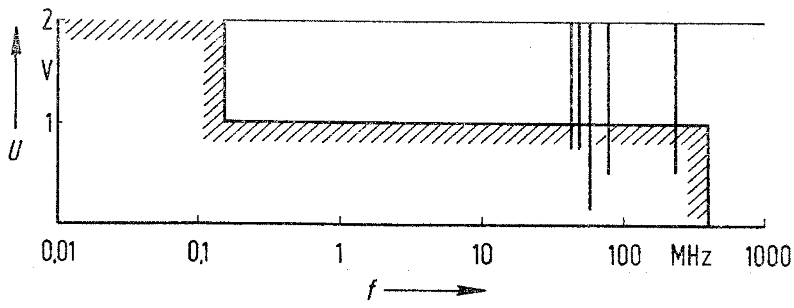

Figure 4

Conducted sine wave interference susceptibility of a weighing machine

Hatched : EEC-limits (extend to 11 V for f ⩽ 150 kHz).
Vertical lines : false weight display.

Pulses :

2 000 V pulses are required with a rise time of 0.1 μs and a decay time of 10 μs in common-mode and series-mode starting from 50 Ω. Test instruments of this capacity were not available. Instead, the tests were carried out with 600 V pulses, and all the weighing machines functioned faultlessly.

Electrostatic discharge :

All the weighing machines stood a discharge of 6 kV with an energy of 2 mJ on the earthed chassis without interference.

Magnetic field :

The EEC draft further provides for a test in an alternating magnetic field with 50 Hz. Field strengths up to 60 A/m must be compatible for the instruments tested.

For this test, a Helmholtz coil system with a diameter of 2r = 1 m and 30 windings was employed. The homogeneity of the field from the centre of the system up to a circumference of r/2 is better than 10 % [10].

The weighing machines described in section 3 were exposed in all three directions to a field of 170 A/m, where they functioned faultlessly.

6. Conclusion

Except for extreme conditions (immediate vicinity of a transmitter, thunderstorms) the requirements of the EEC draft lie within realistic orders of magnitude. The frequency range covered by the requirements should possibly be extended downwards. Data on interference levels which may be found in this range still have to be gathered. For the lowest frequencies, approximately < 50 kHz, a reference to the magnetic field would be reasonable.

Because of the unavoidable difficulties occurring in the test in the near field, the purely numerical data of the draft still have to be supplemented by measurement regulations.

Compliance with the requirements does not seem to cause insurmountable difficulties, as the conditions have already now been met, but for a few exceptions. It is true that false displays also occurred without an operational error having been indicated. This seems to occur mainly in those devices where the measured value is formed electrically. During the rest of the electronic processing (price computer) no fault was detected.

The question remains as to what influence interference fields may have during the settling time of the weighing machine. Here an increased susceptibility to interference can be expected, particularly in the case of incremental transducers.

It should also be clarified to what extent tests on individual specimens can be representative of the behaviour of all instruments in a series. As extensive effort and financial outlay is involved and no own testing apparatus was available, these problems could not be investigated.

We are greatly indebted to the « Erprobungsstelle 81 der Bundeswehr » (Test centre of the German Federal Armed Forces) in Greding where all tests described here were carried out, with the exception of the magnetic field experiment. Mr. Ruffing and Mr. Aloe in particular have assisted us by word and deed.

We wish to thank our colleagues of laboratory 1.33 of the PTB, (Electromagnetic Weighing Machines) for the selection of the weighing machines which were put at our disposal and for their readiness to provide us with information.

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INFORMATIONS

MEMBRES DU COMITE

L'Ambassade d'IRLANDE à Paris nous informe du départ à la retraite de Monsieur J.E. CUNNINGHAM, Principal Officer, Department of Trade, Commerce and Tourism, et de son remplacement dans ses fonctions par Monsieur M. FAHY, qui représentera ainsi son Pays au Comité International de Métrologie Légale. En souhaitant une longue et prospère retraite à Monsieur CUNNINGHAM avec nos remerciements pour sa collaboration avec notre Institution, nous adressons à son successeur, Monsieur FAHY, nos salutations les meilleures de bienvenue.

ETATS-UNIS D'AMERIQUE

Un séminaire sur la mesure des interférences parasites électromagnétiques était organisé par le National Bureau of Standards à Boulder, Colorado, du 25 au 27 août 1981. Le but était d'instruire des ingénieurs électroniciens dans les problèmes de mesures particuliers aux interférences électromagnétiques (EMI) comprenant les techniques de génération de champs, l'utilisation des cellules type TEM ou des chambres anéchoïques, des antennes d'émission et réception, surveillance de l'environnement du point de vue interférences électromagnétiques, etc. Les cours donnés à cette occasion ont été rassemblés dans une reliure à feuillets, qui constitue un outil précieux pour l'ingénieur électronicien qui doit entreprendre des mesures d'interférences électromagnétiques de plus en plus nécessaires dans les activités des services nationaux de métrologie.

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Le sixième symposium international intitulé « Temperature, its Measurement in Science and Industry » organisé conjointement par l'American Institute of Physics, l'Instrument Society of America et le National Bureau of Standards aura lieu à Washington du 15 au 18 mars 1982. Les communications publiées de ces conférences constituent habituellement des sources de référence pour tous travaux de thermométrie.

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Le National Scale Men's Association a publié « The Scalemen's Handbook of Metrology » qui est à la fois un livre d'enseignement et un manuel pratique s'adressant à des techniciens du pesage. Le livre contient 278 pages et 250 illustrations et tableaux. Il couvre les chapitres de balances mécaniques, technique hydraulique, balances électroniques, dispositifs électroniques, détection de défauts de systèmes, pesage de réservoirs, essais et tolérances.

Ce livre est conçu sous forme de feuillets à trois trous mais une reliure peut sur demande également être obtenue de l'éditeur :

National Scale Men's Association
800 S. Milwaukee Avenue
Suite 101
Libertyville IL 60048
U.S.A.

AMERIQUE DU SUD

Le « Sistema Interamericano de Metrologia » dont nous avions annoncé la création dans le Bulletin N° 78, est très actif.

En plus de la publication de la revue « Carta Metrologica » dont nous avons maintenant reçu le Numéro 3, le Sistema Interamericano de Metrologia a publié une version en espagnol du Vocabulaire de l'OIML. Ce vocabulaire intitulé

VOCABULARIO DE METROLOGIA LEGAL

Terminos fundamentales

peut être obtenu de

Instituto Nacional de Tecnologia Industrial
Departamento de Fisica
Direccion Postal SIM-INTI C.C. 157
1650 San Martin B.A.
Argentina

Un accord de collaboration avec l'OIML sera d'ailleurs établi très prochainement.

REPUBLIQUE ARABE D'EGYPTE

Le BIML a reçu du Dr A. EL-TAWIL, Directeur des Laboratoires Métrologiques de l'Organisation Egyptienne de Normalisation (EOS), une description du mode opératoire de calcul, comprenant les listes de programmes, en utilisant un calculateur de poche à cartes magnétiques type TI-59 pour les problèmes suivants :

— calcul des masses à l'aide de la méthode de pesée par double substitution
— calcul du volume d'un étalon de capacité liquide par la méthode gravimétrique
— calcul de l'écart type des balances de précision
— calcul de l'erreur maximale et conditions de réglage optimal de l'étendue d'inclinaison (indication à aiguille ou optique) de balances de précision.

Ces programmes peuvent être obtenus au BIML, sur demande.

ROYAUME-UNI

Le National Weights and Measures Laboratory fait connaître dans une brochure intitulée « Pattern Examination of Weighing or Measuring Equipment — the new procedures » que l'examen en cours de conception « in process examination (IPE) » sera, à partir du 1er janvier 1982, progressivement introduit de façon à permettre que l'approbation de modèle commence à un stade préliminaire de la conception d'une pièce d'équipement avant que la version finale ne soit disponible comme cela a été exigé jusqu'ici. Le demandeur peut choisir entre, soit une consultation très étendue avec discussions et visites à l'usine, soit une consultation minimale avec une seule visite. La consultation peut comprendre, dans certains cas, la validation des résultats d'essais présentés par le fabricant ainsi que l'utilisation de ses installations et méthodes d'essais comme faisant partie du procédé d'approbation. On s'attend à ce que ces arrangements, plus flexibles et optionnels, vont diminuer le risque que de nouveaux modèles ne soient refusés et qu'ils aideront les fabricants dans leur planification de nouveaux produits.

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Le 22 octobre 1981 est la date départ du système national d'agrément des laboratoires d'essais, the National Laboratory Accreditation Scheme (NATLAS) dont les buts sont d'établir la reconnaissance de la compétence des laboratoires d'essais, de constituer une autorité pouvant être consultée en ce qui concerne les laboratoires d'essais en Grande-Bretagne et de promouvoir la reconnaissance internationale de la compétence des laboratoires accrédités.

L'administration de NATLAS sera basée au National Physical Laboratory à Teddington, tout comme cela est déjà le cas pour le système national d'étalonnage British Calibration Service. Les deux organes vont coopérer et sont conseillés sur leur fonctionnement par l'Advisory Council on Calibration and Measurement, qui dépend du Secrétaire d'Etat pour l'Industrie.

IMEKO

Nous avons reçu d'IMEKO une bibliographie de livres traitant des mesurages et de la métrologie.

Cet ouvrage comprend les titres d'environ 900 livres publiés principalement en anglais, allemand et russe jusqu'en 1977 et constitue un outil de travail précieux pour celui qui est à la recherche de livres de métrologie. On peut regretter toutefois qu'il ne comporte que quelques titres en français et que la classification, qui suit probablement les habitudes de bibliothécaires ne soit pas très pratique pour le métrologiste. Il est aussi nécessaire de signaler que beaucoup des livres indiqués sont déjà épuisés chez les éditeurs.

Cette bibliographie s'intitule :

> « A working list of books published on measurement science and technology in the physical sciences »
>
> edited by P.H. Sydenham on behalf of IMEKO TC-1 Committee, May 1980.

Des copies peuvent être obtenues de :

> Delft University of Technology
> Department of Applied Physics
> P.O. Box 5046
> 2600 GA Delft
> Pays-Bas.

*
**

IMEKO fait savoir que le programme de son 9e Congrès qui se tiendra à Berlin (Ouest) du 24 au 28 mai 1982, avec pour titre « Technical and Methodological Advances in Measurement », comprendra plus de 200 exposés. Le programme ainsi que des formulaires d'enregistrement peuvent être obtenus auprès de

> VDI/VDE Gesselschaft Mess- und Regelungstechnik
> D-4000 Düsseldorf 1, Postfach 1139, R.F. d'Allemagne

ou à IMEKO Secrétariat, POB 457, H-1371 Budapest, Hongrie.

INFORMATION

COMMITTEE MEMBERS

The Embassy of IRELAND has informed us that Mr J.E. CUNNINGHAM, Principal Officer, Department of Trade, Commerce and Tourism, has retired and will be replaced by Mr M. FAHY who will represent his country on the International Committee of Legal Metrology. We wish Mr CUNNINGHAM a long and happy retirement and thank him for his collaboration with our Institution ; at the same time we extend a warm welcome to his successor Mr FAHY.

U.S.A.

A seminar on electromagnetic interference (EMI) was organised by the National Bureau of Standards at Boulder, Colorado, from 25 to 27 August 1981. The aim was to familiarize electronic engineers with the particular measurement problems of electromagnetic interference including techniques for generating standard fields, the use of the transverse electromagnetic (TEM) cell and anechoic chambers for susceptibility or radiated emission measurements, antennas and probes, environmental interference monitoring etc. The various lectures given have been collected in a loose leaf bound book ; it is a valuable tool for the electronic engineer who wants to undertake EMI measurements which seem to be more and more required as a part of national metrology activities.

*
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The Sixth International Symposium entitled « Temperature, its Measurement in Science and Industry » sponsored by the American Institute of Physics, the Instrument Society of America and the National Bureau of Standards will take place in Washington D.C. 15 to 18 March 1982. The proceedings of these conferences usually constitute reference sources for all work on thermometry.

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The National Scale Men's Association has published the « Scalemen's Handbook of Metrology » which is both, a tutorial and a practical instruction book for weighing machine technicians. The book has 278 pages and contains 250 illustrations and tables. It covers the following chapters : mechanical scales, hydraulics, electronic scales, instrumentation, system trouble-shooting and calibration, tank and batch weighing, tests and tolerances.

The book is in loose leaf form with a three hole system but a binder may also be obtained from the publishers :

National Scale Men's Association
800 S. Milwaukee Avenue
Suite 101
Libertyville IL 60048
U.S.A.

SOUTH AMERICA

The « Sistema Interamericano de Metrologia », the creation of which was announced in the OIML Bulletin No. 78, is very active.

In addition to the publication of the magazine « Carta Metrologica » of which we have now received No. 3, the Sistema Interamericano de Metrologia has published a Spanish version of the OIML Vocabulary. This vocabulary is entitled

VOCABULARIO DE METROLOGIA LEGAL
Terminos fundamentales

and may be obtained from

Instituto Nacional de Tecnologia Industrial
Departamento de Fisica
Direccion Postal SIM-INTI C.C. 157
1650 San Martin B.A.
Argentina

A collaboration agreement with OIML will be established shortly.

ARAB REPUBLIC OF EGYPT

The BIML has received from Dr A. EL-TAWIL, Director of the Metrology Laboratories of the Egyptian Standards Organisation, a description of the calculations including programme lists using a TI-59 pocket calculator with magnetic cards for the following problems :

- computation of the mass using double substitution weighing,
- computation of the volume of a liquid volume standard using the gravimetric method,
- computation of the standard deviation of precision balances,
- computation of the maximum error and the optimum adjustment of the inclination range (indication by pointer or optical system) of precision balances.

These programmes may be obtained from BIML.

UNITED KINGDOM

The National Weights and Measures Laboratory announces in a booklet « Pattern Examination of Weighing or Measuring Equipment — the new procedures » that « in-process examination (IPE) » will, starting from 1 January 1982, be introduced progressively so as to enable the pattern examination to start early in the development of a piece of equipment before an engineered version of the final design is available, as is required by the traditional procedure. The applicant may choose whether to have extensive early involvement with discussions and works visits or minimal involvement with just a single consultation visit. The involvement may cover, in appropriate circumstances, the validation of test results offered by a manufacturer and the use of his facilities and test procedure as part of the examination. It is expected that these more flexible and optional examination arrangements will help to minimise the risk of new patterns being rejected and will aid manufacturers in planning new products.

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**

The National Testing Laboratory Accreditation Scheme (NATLAS) was launched on 22 October 1981. The scheme is intended to establish widespread recognition of the competence of testing laboratories, to provide an authoritative spokesman for British testing laboratories and to foster the international recognition of the competence of accredited laboratories.

The Administration of NATLAS will be based at the National Physical Laboratory in Teddington as is already the case for the British Calibration Service. Both will cooperate and are advised on their running by the Advisory Council on Calibration and Measurement which reports to the Secretary of State for Industry.

IMEKO

We have received from IMEKO a bibliography of books on measurement science and technology.

This volume contains about 900 entries on books, published mainly in English, German and Russian up to 1977 and constitutes a good working tool for those who are looking for books on metrology. The classification which probably follows the habits of librarians is unfortunately not very practical for the metrologist. Furthermore, it must be pointed out that many of the books mentioned are already out of print.

This bibliography is entitled :

> « A working list of books published on measurement science and technology in the physical sciences »
>
> edited by P.H. Sydenham on behalf of IMEKO TC-1 Committee, May 1980.

Copies may be obtained from

Delft University of Technology
Department of Applied Physics
P.O. Box 5046
2600 GA Delft
The Netherlands.

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IMEKO announces that the final programme of its forthcoming 9th World Congress to be held in Berlin (West) 24-28 May 1982 with the headline « Technical and Methodological Advances in Measurement » will comprise more than 200 papers. The programme and registration forms may be obtained from

VDI/VDE Gesellschaft Mess- und Regelungstechnik
D-4000 Düsseldorf 1, Postfach 1139, F.R. of Germany

or from IMEKO Secretariat, POB 457, H-1371 Budapest, Hungary.

REUNIONS

	Groupes de travail	Dates	Lieux
SP 1 - Sr 1	Vocabulaire de Métrologie Légale - Termes fondamentaux	4-5 février 1982	BIML
SP 14	Acoustique et vibrations	23-24 février 1982	BRAUNSCHWEIG REP. FED. D'ALLEMAGNE
SP 14 - Sr 1	Sons et bruits		
SP 14 - Sr 2	Audiomètres		
SP 14 - Sr 3	Vibrations mécaniques et chocs		
SP 21 - Sr 1	Caractéristiques métrologiques normalisées des instruments de mesurage lors du mesurage des quantités constantes dans le temps	19-27 avril 1982	SOUCHOUMI U.R.S.S.
SP 21 - Sr 2	Caractéristiques métrologiques normalisées des instruments de mesurage lors du mesurage des quantités variables dans le temps		
SP 21 - Sr 4	Caractéristiques métrologiques normalisées des systèmes de mesurage		
SP 19 - Sr 2	Machines d'essai des matériaux	11-14 mai 1982	BIML
SP 7 - Sr 2	Mesurage des masses - généralités - dispositifs électroniques	17-19 mai 1982	BIML
SP 26 - Sr 4	Instruments de mesure bioélectriques	24-30 mai 1982 *(provisoire)*	ROSTOV U.R.S.S.
SP 5 - Sr 1	Mesurage des volumes de liquides. Terminologie	8-10 sept. 1982 *(provisoire)*	LONDRES ROYAUME-UNI ou MUNICH REP. FED. D'ALLEMAGNE
SP 5 - Sr 2	Schémas de hiérarchie des étalons de volume		
SP 5 - Sr 3	Mesures de volumes de laboratoires		
SP 7 - Sr 4	Instruments de pesage à fonctionnement non automatique	13-15 sept. 1982 *(provisoire)*	MUNICH REP. FED. D'ALLEMAGNE

SP 7 - Sr 5	Instruments de pesage à fonctionnement automatique	16 et 17 sept. 1982 *(provisoire)*	MUNICH REP. FED. D'ALLEMAGNE
SP 7	Mesurage des masses	17 sept. 1982 *(provisoire)*	MUNICH REP. FED. D'ALLEMAGNE
SP 4 - Sr 2	Mesures matérialisées de longueur	deuxième semestre 1982 *(provisoire)*	BIML
SP 4 - Sr 3	Appareils de mesurage de la longueur des tissus, câbles et fils		
SP 4	Mesurage des longueurs, surfaces, angles		
SP 16 - Sr 2	Laboratoires secondaires d'étalonnage en dosimétrie	oct.-nov. 1982 *(provisoire)*	BUDAPEST HONGRIE

Groupe de travail mixte ISO-CEI-BIPM-OIML : « Vocabulaire International de Métrologie »	1-3 février 1982	BIPM
Conseil de Développement	22-23 mars 1982	BIML
Dix-huitième Réunion du Comité International de Métrologie Légale	24-26 mars 1982	PARIS FRANCE

CENTRE DE DOCUMENTATION

Documents reçus au cours du 4e trimestre 1981

BUREAU INTERNATIONAL DES POIDS ET MESURES — BIPM

Procès-Verbaux des séances du Comité International des Poids et Mesures - 69e session, 7-9 octobre 1980 (2e série - Tome 48)

Comité Consultatif de Thermométrie
13e session, 17-19 juin 1980

Comité Consultatif pour la Définition de la Seconde
9e session, 23-25 septembre 1980

ORGANISATION DES NATIONS UNIES POUR L'EDUCATION, LA SCIENCE ET LA CULTURE — UNESCO

22 C/3 : Rapport du Directeur Général, 1979-1980

Rapports (vol. 2) : Commissions du programme, Commission administrative, Comité juridique (vingt et unième session de la Conférence Générale, Belgrade 23-9 au 28-10-1980)

ORGANISATION INTERNATIONALE DE NORMALISATION — ISO

ISO Normes (en français et en anglais) :

- ISO 649/1-1981 : Verrerie de laboratoire - Aréomètres à masse volumique d'usage général - Partie 1 : Spécifications
- ISO 649/2-1981 : Verrerie de laboratoire - Aréomètres à masse volumique d'usage général - Partie 2 : Méthodes d'essai et d'utilisation
- ISO 719-1981 : Verre - Résistance hydrolytique du verre en grains à 98 °C - Méthode d'essai et classification
- ISO 720-1981 : Verre - Résistance hydrolytique du verre en grains à 121 °C - Méthode d'essai et classification
- ISO 1042-1981 : Verrerie de laboratoire - Fioles jaugées à un trait
- ISO 2715-1981 : Hydrocarbures liquides - Mesurage volumétrique au moyen de compteurs à turbine
- ISO 2909-1981 : Produits pétroliers - Calcul de l'indice de viscosité à partir de la viscosité cinématique
- ISO 3593-1981 : Amidons et fécules - Détermination des cendres
- ISO 3830-1981 : Produits pétroliers - Essence - Détermination de la teneur en plomb - Méthode au monochlorure d'iode
- ISO 5805-1981 : Chocs et vibrations mécaniques affectant l'homme - Vocabulaire
- ISO 6506-1981 : Matériaux métalliques - Essai de dureté - Essai Brinell
- ISO 6568-1981 : Gaz naturel - Analyse simple par chromatographie en phase gazeuse
- ISO 6743/2-1981 : Lubrifiants, huiles industrielles et produits connexes (classe L) - Classification - Partie 2 : Famille F (Paliers de broche, paliers et embrayages associés)
- ISO 7056-1981 : Matériel de laboratoire en plastique - Béchers
- ISO 7057-1981 : Matériel de laboratoire en plastique - Entonnoirs pour filtration

COMMISSION ELECTROTECHNIQUE INTERNATIONALE — CEI

Rapport annuel, 1980

Modifications à l'Annuaire de la CEI, 1981 (2e série, sept. 1981)

INTERNATIONAL FEDERATION OF CLINICAL CHEMISTRY — IFCC

Annual report for 1980

INTERNATIONAL ATOMIC ENERGY AGENCY — IAEA

Catalogue 1981-82

REUNION INTERNATIONALE DES LABORATOIRES D'ESSAIS ET DE RECHERCHES SUR LES MATERIAUX ET LES CONSTRUCTIONS — RILEM

Statuts généraux, 1re édition, 1981

CONSEIL D'ASSISTANCE ECONOMIQUE MUTUELLE — SEV

Ukazatel' Standartov SEV, 1981

COMMONWEALTH SCIENCE COUNCIL — CSC

CSC (81) MS-14 : Asia/Pacific Metrology programme - Report on a time and frequency intercomparison (by B.M. Lohrey, New Zealand - May 1981)

CSC (81) SQC-9 : African Programme on Standardization and Quality Control - Report of a Metrication Workshop. Vol. I : Proceedings (Jan. 1981 - Swaziland)

CSC (81) SQC-10 : African Programme on Standardization and Quality Control - Report of a Metrication Workshop. Vol. II : Resource Material (Jan. 1981, Swaziland)

CSC (81) SQC-11 : African Programme on Standardization and Quality Control - Directory of calibration and testing facilities (by F.M. Banda, Malawi - August 1981)

CSC (81) SQC-12 : African Programme on Standardization and Quality Control - Report on the Third Steering Committee Meeting (14-16 Jan. 1981, Botswana - August 1981)

SISTEMA INTERAMERICANO DE METROLOGIA — SIM

Publications

Carta Metrologica

Vocabulario de Metrologia Legal, Terminos fundamentales (Traduction en espagnol de la version officielle française, édition 1978), mai 1981

INTERNATIONAL MEASUREMENT CONFEDERATION — IMEKO

Technical Committee TC-1, Higher Education

A working list of books published on measurement science and technology in the physical sciences (edited by P.H. Sydenham, Sept. 1980)

REPUBLIQUE FEDERALE D'ALLEMAGNE

Physikalisch- Technische Bundesanstalt

Dritte Verordnung zur Änderung der Ausführungsverordnung zum Gesetz über Einheiten im Messwesen vom 8-5-1981

ETATS-UNIS D'AMERIQUE

National Scalemen's Association

Scalemen's Handbook of Metrology, 1980

National Bureau of Standards

NBS EMI Metrology Seminar, August 25-27, 1981
Weights and Measures Directory, 1981 (State offices and Country/city offices)

BOTSWANA

Department of Weights and Measures

Report on the Weights and Measures Administration for the period 1st April 1979 to 31st March 1981 (Gaborone, June 1981)

REPUBLIQUE POPULAIRE DE CHINE

State Bureau of Metrology

Proposed Plan on Terminology and Symbols for Units and Weights and Measures (in Chinese and in English, March 1981)

International System of Units (revised version in Chinese, 1981)

CUBA

Comité Estatal de Normalizacion

Instruccion Normalizativa Cubana - (INC) :

INC-21:80	Systema Nacional de Normalizacion, Metrologia y Control de la Calidad - Certificacion de concordancia
INC-45:80	Indicaciones metodologicas para la implantacion de las normas
INC-46:80	Control de la Calidad - Fiabilidad - Metodologia para la seleccion de la nomenclatura de los indices de fiabilidad de los articulos industriales

Normas Cubanas - (NC) :

NC 90-00-01:80	Sistema de Normas del Aseguramiento Metrologico - Principios generales
NC 90-01-17:80	Cintas metalicas de medicion - Metodo y medios de verificacion
NC 90-04-02:80	Medidas de capacidad de vidrio - Clasificacion
NC 90-04-04:81	Recipientes metalicos para la medicion de volumen - Clasificacion
NC 90-04-05:81	Recipientes metalicos patrones de 2, 5, 10 y 20 dm^3 - Caracteristicas tecnicas
NC 90-04-17:81	Metodos y medios de medicion de volumen - Terminos y definiciones
NC 90-11-02:80	Medios de medicion de tiempo y frecuencia - Esquema de trasmision nacional
NC 90-13-06:80	Polarimetros y sacarimetros - Reglas generales para efectuar determinaciones polarimetricas y sacarimetricas
NC 90-13-15:81	Medidores de pH - Clasificacion
NC 90-14-01:80	Termometros de resistencia de trabajo - Metodos y medios de verificacion
NC 90-14-05:80	Termometros clinicos - Metodos y medios de verificacion
NC 90-15-01:81	Electrometria - Clases de precision. Simbolos
NC 90-15-09:80	Wattimetros - Metodos y medios de verificacion (Metodo de compensacion)
NC 90-15-13:80	Compensadores de medicion de corriente directa - Metodos y medios de verificacion
NC 90-19-02:81	Frecuencimetros electricos - Metodos y medios de verificacion
NC 92-18:80	Control de la calidad - Eficacia de los docimos de la media y la varianza
NC 92-04-1:80	Control de la calidad - Guia para el uso de la NC 92-04 « Inspeccion por atributos y por contes de defectos. Planes de muestres de aceptacion »

DANEMARK

Dansk Institut for Provning og Justering

Nouvelle publication : DANTESTNYT, Oct. 1981

FRANCE

Bureau National de Métrologie

Rapport d'activité, 1980

Monographie n° 7 : Introduction aux techniques de conditionnement des laboratoires (U. Zelbstein, Editions Chiron, 1980)

Laboratoire National d'Essais

Rapport d'activité, 1980

Commission Industrie-Administration pour la Mesure - CIAME

5e Exposition des Capteurs Français (Palais des Congrès à Versailles, du 6 au 9 octobre 1981)

Réglementation

Circulaire n° 81.1.01.400.0.3 du 30-4-1981 sur le contrôle des ensembles de mesurage volumétriques des carburants pour véhicules routiers

Arrêté du 8-5-1981 modifiant l'arrêté du 26-6-1980 relatif à la construction, le jaugeage et l'utilisation des cuves de refroidisseurs de lait en vrac

ROYAUME-UNI DE GRANDE-BRETAGNE ET D'IRLANDE DU NORD

Metrology, Quality Assurance, Safety and Standards Division

Supplement to Manual of practical guidance for Inspectors (Weights and Measures Act 1979) - Random Sampling Numbers, 1980

Quantity marking for prepackaged wine - Practical notes for Inspectors of Weights and Measures on the Prepackaging and Labelling of Wine and Grape Must (EEC Requirements) Regulations 1978, 1978

Advanced Statistics Course for Trading Standards Officers - Felixstowe Court, Bristol Polytechnic, oct. 1980

Weights and Measures Act 1979, chapter 45 : Packaged Goods and Amendments of Weights and Measures Act 1963

Statutory Instruments 1980 n° 1064 : Weights and Measures - The Weights and Measures (Packaged Goods) (Amendment) Regulations 1980

Statutory Instruments 1981 n° 1306 : Weights and Measures - The Measuring Instruments (Liquid fuel and lubricants) (Amendment) Regulations 1981

Nalgo Correspondence Institute

Study Material on Statistics for qualified Inspectors of Weights and Measures, 1981

MEXIQUE

Reunion del Sistema Integrado de Normalizacion, Metrologia y Calidad

Documentation complète de la réunion qui s'est tenue à Acapulco du 22 au 25 septembre 1981

POLOGNE

Polski Komitet Normalizacj, Miar i Jakosci

Dziennik Normalizacji i Miar : Nr 8 à 13/1981

Instrukcje z dnia 15-4-1981 r. o sprawdzaniu :
- Nr 1 plitek wzorcowych za pomoca cyfromych czujnikow elektronicznych
- Nr 2 czujnikow mechanicznych z dzialka elementarna o wartosci 1 µm i 2 µm
- Nr 3 projektorow pomiarowych
- Nr 4 poziomic stalych metalowych dwukierunkowych

Zarzodzenie z dnia 8-5-1981 r. w sprawie ustalenia przepisow :
- Nr 78 o plaskorownoleglych plytach interferencyjnych
- Nr 79 o wlasciwym stosowaniu gestosciomierzy zbozowych kontrolnych III rzedu i gestosciomierzy uzytkowych

Zarzadzenie z dnia 8-5-1981 r. zmieniajace :
- Nr 80 przepisy o beczkach
- Nr 81 instrukcje o sprawdzaniu kontrolnych wzorcow pola elektromagnetycznego w zakresie czestotliwosci (0,1 - 30) MHz

Zarzadzenia n° 92 z dnia 12-6-1981 r. w sprawie ustalenia przeprisow o uzytkowych licznikach energ elektrycznej pradu przemiennego

Zarzadzenia z dnia 30-6-1981 r. w sprawie ustalenia przeprisow :
- Nr 108 o gazomierzach komorowych
- Nr 109 o obciaznikach

URSS

Gosudarstvennyj Komitet Standartov Soveta Ministrov SSSR

Gosudarstvennye Standarty SSSR, 1981 (3 tomes)

State system for ensuring the uniformity of measurements :

Gost 8.016-81 : State primary standard and state verification schedule for means measuring plane angle

Gost 8.027-81 : State primary standard and state verification schedule for measuring instruments of electromotive force and direct current

Gost 8.195-81 : State primary standard and state verification schedule for means measuring radiant intensity and irradiance of continuous optical radiation of continuous spectrum in the wavelength range from 0.2 to 10.6 μm

Gost 8.196-81 : State primary standard and state verification schedule for means measuring spectral density of radiance, spectral density of radiant intensity and spectral density of irradiance of continuous optical radiation in the wavelength range from 0.22 to 10.6 μm

Gost 8.197-76 : State primary standard and state verification schedule for means measuring spectral density of energy radiation of optical radiation in the wavelength range from 0.05 to 25 μm

Gost 8.412-81 : State primary standard and state verification schedule for means measuring relative dielectric constant at frequency range from 1 to 200 MHz

Gost 8.418-81 : State primary standard and state verification schedule for means measuring relative distribution of energy density in cross-section and energy divergence angle of pulse laser radiation beam in the wavelength range from 0.4 to 12.0 μm

Gost 8.419-81 : Radio interference measuring apparatus. Methods and means of verification

Gost 8.420-81 : State special standard and state verification schedule for means of measuring straightness and flatness deviation

Gost 8.421-81 : State special standard and state verification schedule for measuring temperatures from 10^3 to 10^5 K in the microwave spectrum

Gost 8.423-81 : Mechanical stop watches. Methods and means for verification

Gost 8.425-81 : Machine for testing metal fatigue. Methods and means for verification

Gost 8.426-81 : Shore rebound hardness testing machines. Methods and means of verification

Gost 8.430-81 : Units of physical quantities, symbols of the units for printing devices with a limited set of signs.

RECOMMANDATIONS INTERNATIONALES

de la

CONFERENCE INTERNATIONALE DE METROLOGIE LEGALE

R.I. N°		Secrétariats	Année d'édition
—	Vocabulaire de métrologie légale (termes fondamentaux) (édition bilingue français/anglais)	Pologne	1978
1 —	Poids cylindriques de 1 gramme à 10 kilogrammes (de la classe de précision moyenne)	Belgique	1973
2 —	Poids parallélépipédiques de 5 à 50 kilogrammes (de la classe de précision moyenne)	Belgique	1973
3 —	Réglementation métrologique des instruments de pesage à fonctionnement non automatique	R.F. d'Allemagne et France	1978
4 —	Fioles jaugées (à un trait) en verre	Royaume-Uni	1970
5 —	Compteurs de volume de liquides (autres que l'eau) à chambres mesureuses	R.F. d'Allemagne et France	1981
6 —	Prescriptions générales pour les compteurs de volume de gaz	Pays-Bas et R.F. d'Allemagne	1978
7 —	Thermomètres médicaux à mercure, en verre, avec dispositif à maximum	R.F. d'Allemagne	1978
8 —	Méthode étalon de travail destinée à la vérification des instruments de mesurage du degré d'humidité des grains	R.F. d'Allemagne	1970
9 —	Vérification et étalonnage des blocs de référence de dureté Brinell	Autriche	1970
10 —	de dureté Vickers		
11 —	de dureté Rockwell B		
12 —	de dureté Rockwell C		
13 —	Symbole de correspondance	B.I.M.L.	1970
14 —	Saccharimètres polarimétriques	R.F. d'Allemagne	1978
15 —	Instruments de mesure de la masse à l'hectolitre des céréales	R.F. d'Allemagne	1970
16 —	Manomètres des instruments de mesure de la tension artérielle	Autriche	1970
17 —	Manomètres - vacuomètres - manovacuomètres - indicateurs (instruments usuels)	U.R.S.S.	1981
18 —	Pyromètres optiques à filament disparaissant	U.R.S.S.	1970

19 —	Manomètres - vacuomètres - manovacuomètres - enregistreurs (instruments usuels)	U.R.S.S.	1981
20 —	Poids des classes de précision E_1 E_2 F_1 F_2 M_1 de 50 kg à 1 mg	Belgique	1973
21 —	Taximètres	R.F. d'Allemagne	1973
22 —	Alcoométrie	France	1973
—	Tables alcoométriques	France	1975
23 —	Manomètres pour pneumatiques	U.R.S.S.	1973
24 —	Mètre étalon rigide pour Agents de vérification	Inde	1973
25 —	Poids étalons pour Agents de vérification	Inde	1977
26 —	Seringues médicales	Autriche	1973
27 —	Compteurs de volume de liquides autres que l'eau — Dispositifs complémentaires	R.F. d'Allemagne et France	1973
28 —	Réglementation « technique » des instruments de pesage à fonctionnement non-automatique	R.F. d'Allemagne et France	1981
29 —	Mesures de capacité de service	Suisse	1973
30 —	Mesures de longueur à bouts plans	U.R.S.S.	1981
31 —	Compteurs de volume de gaz à parois déformables	Pays-Bas	1973
32 —	Compteurs de volume de gaz à pistons rotatifs et compteurs de volume de gaz à turbine	R.F. d'Allemagne	1973
33 —	Valeur conventionnelle du résultat des pesées dans l'air	B.I.M.L.	1973
34 —	Classes de précision des instruments de mesurage	U.R.S.S.	1974
35 —	Mesures matérialisées de longueur pour usages généraux	Belgique et Hongrie	1977
36 —	Vérification des pénétrateurs des machines d'essai de dureté	Autriche	1977
37 —	Vérification des machines d'essai de dureté système Brinell	Autriche	1977
38 —	Vérification des machines d'essai de dureté système Vickers	Autriche	1977
39 —	Vérification des machines d'essai de dureté système Rockwell B,F,T — C,A,N	Autriche	1977
40 —	Pipettes étalons pour Agents de vérification	Inde	1977
41 —	Burettes étalons pour Agents de vérification	Inde	1977
42 —	Poinçons de métal pour Agents de vérification	Inde	1977
43 —	Fioles étalons graduées en verre pour Agents de vérification	Inde	1977
44 —	Alcoomètres et aréomètres pour alcool	France	1977

45 —	Tonneaux et futailles	Autriche	1977
46 —	Compteurs d'énergie électrique active à branchement direct	France	1978
47 —	Poids étalons pour le contrôle des instruments de pesage de portée élevée	R.F. d'Allemagne et France	1978
48 —	Lampes à ruban de tungstène pour l'étalonnage des pyromètres optiques	U.R.S.S.	1978
49 —	Compteurs d'eau (destinés au mesurage de l'eau froide)	Royaume-Uni	1977
50 —	Instruments de pesage totalisateurs continus à fonctionnement automatique	Royaume-Uni	1980
51 —	Trieuses pondérales de contrôle et trieuses pondérales de classement	Royaume-Uni	1980
52 —	Poids hexagonaux — Classe de précision ordinaire — de 100 grammes à 50 kilogrammes	Belgique et Royaume-Uni	1980
53 —	Caractéristiques métrologiques des éléments récepteurs élastiques utilisés pour le mesurage de la pression	U.R.S.S.	*
54 —	Echelle de pH des solutions aqueuses	U.R.S.S.	1981
55 —	Compteurs de vitesse, compteurs mécaniques de distance et chronotachygraphes des véhicules automobiles — Réglementation métrologique	Pologne	1981
56 —	Solutions-étalons, reproduisant la conductivité des électrolytes	U.R.S.S.	1981
57 —	Ensembles de mesurage de liquides autres que l'eau équipés de compteurs de volumes — Dispositions générales	R.F. d'Allemagne et France	

DOCUMENTS INTERNATIONAUX

adoptés par le

Comité International de Métrologie Légale

D.I. N°			
1 —	Loi de métrologie	BIML	1975
2 —	Unités de mesure légales	BIML	1978
3 —	Qualification légale des instruments de mesurage	BIML	1979
4 —	Conditions d'installation et de stockage des compteurs d'eau froide	Royaume-Uni	1981

Note — Recommandations internationales et Documents internationaux peuvent être acquis au Bureau International de Métrologie Légale, 11, rue Turgot, 75009 PARIS.

* En cours de publication.

ORGANISATION INTERNATIONALE DE MÉTROLOGIE LÉGALE

BUREAU INTERNATIONAL DE MÉTROLOGIE LÉGALE
11, RUE TURGOT — 75009 PARIS — FRANCE

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ORGANISATION INTERNATIONALE DE MÉTROLOGIE LÉGALE

BUREAU INTERNATIONAL DE MÉTROLOGIE LÉGALE
11, RUE TURGOT — 75009 PARIS — FRANCE

MEMBRES
du
COMITE INTERNATIONAL de METROLOGIE LEGALE

ALGERIE

Membre à désigner par son Gouvernement

REPUBLIQUE FEDERALE D'ALLEMAGNE

Mr W. MÜHE
Chef des Bureaux Technico-Scientifiques,
Physikalisch-Technische Bundesanstalt,
Bundesallee 100
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REPUBLIQUE DEMOCRATIQUE ALLEMANDE

Mr H.W. LIERS
Directeur de la Métrologie Légale,
Amt für Standardisierung, Messwesen
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Fürstenwalder Damm 388
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ETATS-UNIS D'AMERIQUE

Mr A.O. McCOUBREY
Associate Director for Measurement Services,
National Measurement Laboratory,
Building 221, Room A 363,
National Bureau of Standards
WASHINGTON, D.C. 20234.

REPUBLIQUE ARABE D'EGYPTE

Mr F.A. SOBHY
Président,
Egyptian Organization for standardization,
2 Latin America Street, Garden City
CAIRO.

AUSTRALIE

Mr T.J. PETRY
Executive Director
National Standards Commission,
P.O. Box 282
NORTH RYDE, N.S.W. 2113.

AUTRICHE

Mr F. ROTTER
Chef de la Section de métrologie légale,
Bundesamt für Eich- und Vermessungswesen,
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