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Département de Génie des Procédés et Environnement

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Spécialité : Licence — 2e année, Semestre 3

REGULATION AND STANDARDS

Réglementation et normes

Unité d'enseignement UED 2.1 — VHS 22 h 30 — 1 crédit — coefficient 1

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Contents

List of figures

Course description

Degree	Licence — Industrial Hygiene and Safety (HSI) / Process Engineering (GP), second year
Semester	Semester 3
Teaching unit	UED 2.1 — Discovery unit
Subject	Regulation and standards
Hours	22 h 30 total — lecture 1 h 30 per week, 15 weeks
Credits / coefficient	1 / 1
Assessment	Final written examination — 100 %
Companion subject	HSE of industrial installations, same teaching unit
Lecturer	Dr. Ahmed Cherif Rahmani, Maître de conférences B

Aims of the course

The official aim is to introduce students to regulation and to standardisation, and to impress on them the importance of both in industry, so that they are prepared **to comply with regulation and to use standards**. Expressed as verifiable skills, this means being able to:

1. **situate a text** in the hierarchy of norms and say whether it is mandatory or voluntary, and for whom;
2. **find the applicable standard** for a given product, method or activity, and read its reference correctly;
3. **use the normative parameters of production** — tolerances, fits, interchangeability — and interpret a designation such as ∅40 H7/g6;
4. **distinguish testing, inspection, certification and accreditation**, and say who attests what;
5. **navigate a classification of standards** and construct a search from it.

Why this subject matters to an engineer

A young engineer usually meets regulation as an obstacle and standards as paperwork. Both impressions are wrong, and correcting them is the real purpose of these fifteen weeks.

Regulation exists because some risks are not negotiable. It fixes what a society refuses to leave to the judgement of each producer: that a pressure vessel shall not burst, that an effluent shall not poison a river, that a worker shall not lose his hearing. It is written by a public authority, it is mandatory, and its breach is punished.

Standards exist because production without common references is impossible. A bolt made in one country must fit a nut made in another; a laboratory result must mean the same thing in two cities; a safety level must be comparable between two suppliers. Standards are written by consensus of the interested parties, they are voluntary by default, and they are the accumulated technical memory of an industry.

The two meet at a precise point, and this point is the intellectual centre of the course: **when a regulation refers to a standard, that standard becomes mandatory for that purpose**. Understanding that mechanism is worth more than memorising any list of texts.

Structure and weekly plan

Weeks	Content	Figure	Key skill
1–3	Chapter 1 — Regulation, regulatory texts, and the link between economic development and standardisation	Fig. 2.1, 2.8	Situate a text
4–7	Chapter 2 — Standardisation: object, bodies, international level, Algeria, deliverables, management systems	Fig. 2.2, 2.3, 2.9	Find the right standard
8–11	Chapter 3 — Tolerances and fits, IT grades, surface texture, capability, metrology, conformity control	Fig. 2.4, 2.5, 2.10 to 2.12	Read a fit designation
12–15	Chapter 4 — Classification of products and of standards, codification, the compliance file. Revision	Fig. 2.6, 2.7, 2.13, 2.14	Search a catalogue

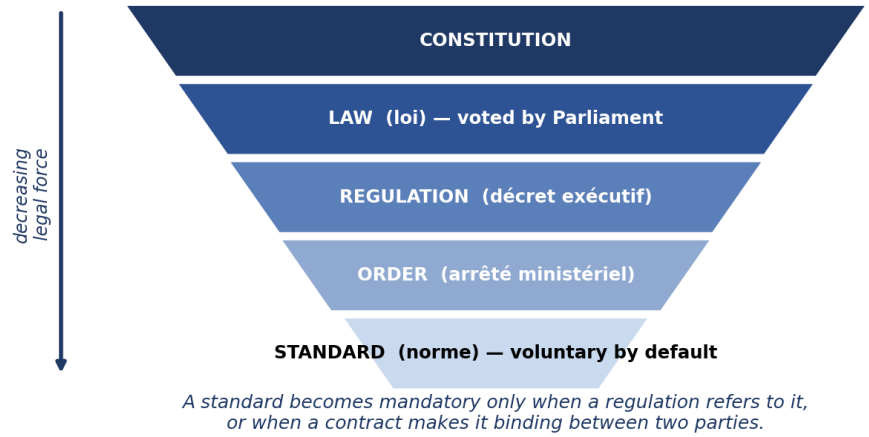
Chapter 1 — Introduction: regulation and standardisation

Three weeks.

1.1 Regulation and regulatory texts

A **norm**, in the general sense, is any rule that prescribes a behaviour. Norms differ by who writes them, by what makes them binding, and by what happens when they are breached. The engineer needs to place any text he is handed on this scale before doing anything else with it.

Figure 2.1 — Hierarchy of norms: where a standard sits



The levels, from the strongest to the weakest

Level	Who adopts it	What it does in our field
Constitution	The people, by referendum	States general principles: the right to health protection, the protection of the environment
Law (loi)	Parliament	Creates obligations and sanctions. Example: the law on occupational hygiene, safety and medicine; the law on environmental protection
Executive decree (décret exécutif)	The executive	Fixes the detailed rules that apply the law: thresholds, procedures, technical prescriptions
Ministerial order (arrêté)	A minister, or several jointly	Fixes particulars: limit values, approved methods, model forms
Standard (norme)	A standards body, by consensus	Voluntary by default. Becomes binding when a regulation refers to it, or when a contract requires it

> **The rule of hierarchy.** A lower text may never contradict a higher one. A ministerial order that went beyond what its decree allows is unlawful, and a standard can never authorise what a regulation forbids. Conversely, nothing prevents a company from being stricter than the regulation, and many are, by contract with their customers.

How to read a regulatory reference

A text is identified by its **nature**, its **number**, its **date** and its **object** — for example: *executive decree no. 06-198 of 31 May 2006 defining the regulations applicable to classified establishments for environmental protection*. Three practical cautions follow.

- **A text may be amended or repealed.** Always check that the version you cite is in force. Citing a repealed article in a professional report is a serious error and destroys the credibility of the whole document.
- **A text has a scope.** It applies to certain activities, above certain thresholds, from a certain date. Half the disputes about compliance are disputes about scope, not about the substance of the rule.
- **Publication in the official journal is what makes the text enforceable.** A draft circulating in a professional association is not law.

The main instruments of our field in Algerian law

Domain	Principal instrument
Occupational health and safety	Law no. 88-07 of 26 January 1988 on occupational hygiene, safety and medicine, and executive decree no. 91-05 of 19 January 1991 on the general prescriptions of protection
Environment	Law no. 03-10 of 19 July 2003 on environmental protection within the framework of sustainable development, and the regime of classified installations
Standardisation	Law no. 04-04 of 23 June 2004 on standardisation, which organises the national system
Consumer protection and conformity	Law on consumer protection and the suppression of fraud, which makes certain standards mandatory for products placed on the market

These references are given so that you know where to look. Verify the version in force before use.

1.2 Economic development and standardisation

Standardisation is not a bureaucratic layer added to industry. Historically, it appeared when industry needed it, and it appeared for a reason that is easy to state.

The origin: interchangeability

As long as an object was made by one craftsman, each part was adjusted to its neighbour and no two objects were identical. A broken part meant a new part made to measure. Mass production is impossible under this condition, because it requires that **any part taken at random from a batch fit any assembly taken at random**. This property is called interchangeability, and it is unattainable without an agreed language of dimensions, tolerances, materials and tests. Standardisation is that language.

What standardisation produces for an economy

Effect	Mechanism
Reduction of costs	Fewer variants, longer production runs, interchangeable spares, shared design effort
Access to markets	A product built to an internationally recognised standard is accepted abroad; a product built to a purely national specification must be re-qualified for every market
Transfer of technology	A standard is a codified, published state of the art. For a developing industry it is the cheapest available engineering knowledge
Safety and public confidence	A common level of performance that the buyer can rely on without testing every item
Reduction of technical barriers to trade	When two countries use the same standard, a test performed in one can be accepted in the other

The point that matters for Algeria, and that is worth developing in an examination answer. For an economy seeking to export outside its region, alignment on international standards is not a formality: it is the condition of access. A producer whose product meets an international standard and can prove it with an accredited test report competes; one who cannot must persuade each buyer separately, and usually loses. This is why the national standards body's adoption policy — how many international standards are taken up as national standards — is an economic policy instrument and not an administrative statistic.

The counterpart: what standardisation costs

An honest course must state the other side. Standardisation slows innovation where a standard freezes a technique that a newcomer would improve; it favours those who sit on the drafting committees, which are dominated by large firms; and compliance has a cost — testing, certification, documentation — which weighs proportionally more on a small enterprise. These effects are real, they are debated, and the answer to them is not to abandon standardisation but to keep the drafting open and the revision periodic.

1.3 Technical barriers to trade

A country may protect its market by a customs duty, which is visible and negotiable. It may also protect it by a technical requirement — a national standard that no foreign producer meets, a test that only a national laboratory may perform, a certification whose delay makes importation impossible. This is a **technical barrier to trade**, and it is far more effective than a duty precisely because it looks like a legitimate protection of health or safety.

The international rule that governs this is the World Trade Organization Agreement on Technical Barriers to Trade. Three of its principles are worth knowing, because they explain most of what national standards bodies do.

- **Necessity.** A technical regulation shall not be more trade-restrictive than necessary to fulfil a legitimate objective — national security, protection of health, of safety, of the environment, prevention of deceptive practices.
- **Use of international standards.** Where an international standard exists, it shall be used as the basis of the national regulation, except where it would be an ineffective means of achieving the objective. This is the legal origin of the policy of adopting ISO standards nationally.
- **Equivalence and mutual recognition.** Members are encouraged to accept the technical regulations of others as equivalent when they fulfil the same objective, and to recognise each other's conformity assessment results.

The practical consequence for an Algerian producer. A product built to a national standard that diverges from the international one must be re-designed or re-tested for every export market, and the cost of that duplication falls entirely on the exporter. A product built to the international standard, tested by a laboratory accredited under a recognised arrangement, is accepted on the strength of a single test report. **Standardisation policy is therefore export policy**, and this is the argument to develop if an examination question asks why standardisation matters to a developing economy.

1.4 Exercises — chapter 1

Exercise 1.1. Place the following in the hierarchy of norms and say whether each is mandatory: (a) a law on environmental protection; (b) ISO 45001; (c) a ministerial order fixing a limit value for a discharge; (d) an internal company procedure; (e) a standard cited by name in a public procurement contract.

Exercise 1.2. A supplier states that his product *complies with the standard*. What three questions must you ask before accepting this statement?

Exercise 1.3. Explain, in ten lines, why interchangeability is impossible without standardisation, using the example of a threaded fastener.

Chapter 2 — Standardisation

Four weeks.

2.1 Object and development of standardisation

A **standard** is a document, established by consensus and approved by a recognised body, that provides rules, guidelines or characteristics for activities or their results, for common and repeated use, with the aim of achieving the optimum degree of order in a given context.

Three elements of that definition deserve attention. **Consensus** is not unanimity: it is the absence of sustained opposition on essential points, which allows a standard to be adopted even when a minority disagrees. **A recognised body** is what separates a standard from a specification written by one firm. **Repeated use** is what distinguishes a standard from a contract: it is written once, for many.

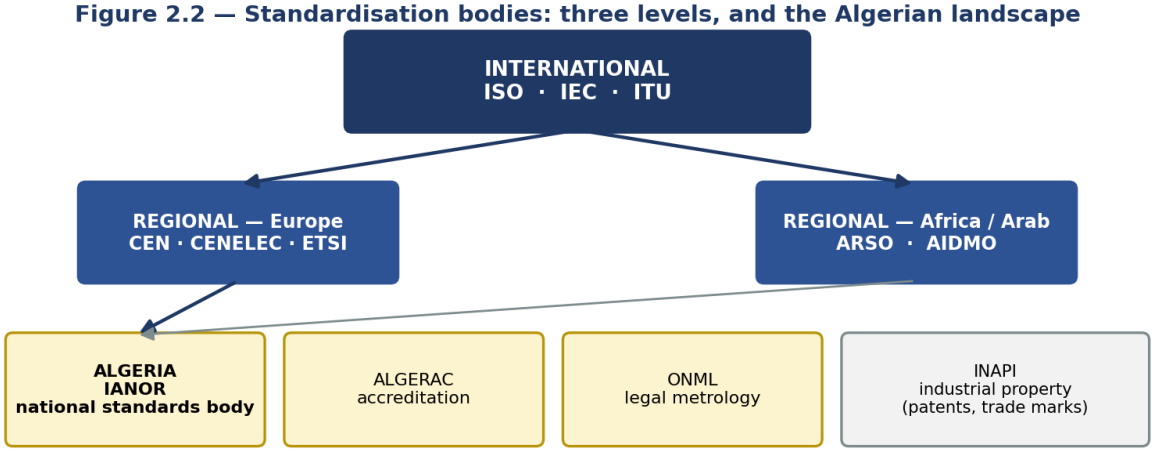
The types of standard

Type	What it fixes	Example
Terminology	Definitions of terms, so that two parties mean the same thing	Vocabulary of quality management
Test method	How a property is measured, so that two laboratories obtain comparable results	Determination of a chemical parameter in water
Specification	The characteristics a product must have	Dimensions and grades of a threaded fastener
Organisation / system	How an activity is managed	ISO 9001 quality, ISO 14001 environment, ISO 45001 occupational health and safety
Guideline	Recommended practice, without requirements	ISO 31000 risk management

> **A distinction that is examined every year.** A standard containing *requirements* — expressed by *shall* — can be certified against. A standard containing *guidance* — expressed by *should* — cannot. ISO 9001 is certifiable; ISO 31000 is not, and any body offering a certificate against it is selling something without value.

2.2 Associations and standardisation bodies

Figure 2.2 — Standardisation bodies: three levels, and the Algerian landscape



Careful: INAPI is NOT the standards body. Since 1998 the national standards body is IANOR; INAPI now deals with industrial property. Older course notes still confuse the two.

The three levels

- **International.** Three bodies share the field: **ISO** for most sectors, **IEC** for electrotechnology, **ITU** for telecommunications. They work by national delegations, one vote per country, through technical committees and subcommittees.
- **Regional.** In Europe, **CEN**, **CENELEC** and **ETSI**, whose standards are transposed identically by the member countries. In Africa, **ARSO**; in the Arab region, the standardisation activity of **AIDMO**.
- **National.** One body per country, which adopts international standards as national standards and develops the standards specific to its country. AFNOR in France, DIN in Germany, BSI in the United Kingdom, ANSI in the United States — and **IANOR** in Algeria.

The Algerian system

Four institutions must not be confused, and confusing them is the most frequent error in this subject.

Body	Mission
IANOR Institut algérien de normalisation	**The national standards body.** Prepares, adopts and publishes Algerian standards (NA), represents Algeria at ISO, and manages the national certification of conformity to standards
ALGERAC Organisme algérien d'accréditation	Accredits conformity assessment bodies — laboratories, inspection bodies, certification bodies — that is, it attests their competence
ONML Office national de métrologie légale	Legal metrology: verification of measuring instruments used in transactions and in regulatory control
INAPI Institut national algérien de la propriété industrielle	Industrial property: patents, trade marks, designs. **It is not the standards body**

An important correction. Many course notes, including the national syllabus of this Licence, still name INAPI as the Algerian standardisation body. That was true historically, when the institute combined standardisation and industrial property. Since the reform of 1998 the two functions are separate: **standardisation belongs to IANOR**, and INAPI deals only with industrial property. Use IANOR in your answers, and know why the older name appears in the documents.

2.3 International standardisation and the life of a standard

Figure 2.3 — The seven stages of an international standard

Typical duration: three years. Consensus, not unanimity, is the decision rule — and every published standard is reviewed at least every five years.

A standard is not written by an author, it is negotiated. The seven stages above describe an ISO standard, and their logic is the progressive widening of the circle of agreement: from a proposal made by one country, to a working draft discussed by experts, to an enquiry open to all member bodies, to a final vote.

Stage	Name	What happens
PWI	Preliminary work item	The subject is placed on the programme, without commitment
NP	New work item proposal	A member body proposes; the committee votes on whether to take it up, and members commit to participate
WD	Working draft	Experts draft the technical content in a working group
CD	Committee draft	First circulation to the committee members for comment; the technical debate takes place here
DIS	Draft international standard	Public enquiry: circulated to all member bodies for vote and comment
FDIS	Final draft	Final vote, on a text no longer open to technical amendment
IS	International standard	Published. Reviewed at least every five years: confirmed, revised, or withdrawn

Two consequences for the user. **A standard takes about three years to produce**, which is why it always lags behind the newest technique — and why a standard cited in a contract must be cited with its year. **A standard is periodically reviewed**, which means that the reference you used two years ago may have been superseded, and that using a withdrawn edition is a real and common error.

Adoption at national level

A national body may adopt an international standard in three ways: **identical**, where the text is taken over without change; **modified**, where national deviations are introduced and must be declared; or by **endorsement**, where the international text is simply declared applicable. Identical adoption is the objective, because it is the only one that guarantees mutual recognition of test results.

2.4 The deliverables of a standards body, and who writes them

A standards body does not publish only standards. It publishes a family of documents whose status differs, and confusing them is a common professional error.

Deliverable	Status	When it is used
IS — International Standard	Full consensus, full procedure, reviewed every five years	The normal case
TS — Technical Specification	Published where consensus is not yet complete, or the subject is still developing	A future standard, tried out in practice first
TR — Technical Report	Informative only: data, a state of the art, a survey. **Contains no requirement**	Background to another standard
PAS — Publicly Available Specification	Produced quickly, often from an industry document, with limited consensus	A fast-moving field
IWA — International Workshop Agreement	Produced in a workshop outside the committee structure	Urgent needs, new subjects

> **The distinction that costs marks.** A technical report cannot be complied with, because it contains no requirement, and cannot be certified against. Writing *our product complies with the technical report* is meaningless. Read the status on the cover page before using a document.

Who actually writes a standard

The work is done in **technical committees** (TC), divided into **subcommittees** (SC) and **working groups** (WG). A committee is composed of national delegations, and each national body decides whether to participate as a **P-member** — participating, with an obligation to vote — or as an **O-member** — observing, receiving the documents without voting. The experts in the working groups are nominated by their national bodies and come from industry, from laboratories, from universities and from administrations.

Two consequences follow, and an honest course states them. **Participation determines influence**: a country that observes without participating receives standards written by others and must then apply them. And **the composition of the committees is not neutral**: large firms can afford to send experts to meetings for years, small ones cannot, which is why standards sometimes codify the practice of the large producers. The remedy is not to reject standardisation but to participate in it, which is precisely the mission of a national body.

2.5 Management system standards and their common structure

The best-known standards are not product standards but **management system standards**, which specify how an organisation shall manage an activity rather than what its products shall be. Three concern us directly.

Standard	Object	What it requires, in one line
ISO 9001	Quality management	Deliver consistently what the customer and the regulation require, and improve
ISO 14001	Environmental management	Identify the environmental aspects, control the significant ones, comply, improve
ISO 45001	Occupational health and safety	Identify the hazards, control the risks, involve the workers, comply, improve

Figure 2.9 — The common structure of management system standards (Annex SL)

Same clause numbering, same core text, same vocabulary. This is what makes an integrated quality–environment–safety system possible, and a combined audit meaningful.

Since 2012 these standards share the **same clause structure**, the same core text and the same vocabulary — clauses 4 to 10 as shown above. This alignment was not cosmetic. It allows an organisation to operate a single integrated system instead of three parallel ones, to be audited once instead of three times, and to write one document where it previously wrote three. For a small enterprise this is the difference between a system that is maintained and one that is abandoned.

Three requirements common to the three standards, and often misunderstood

- **Context and interested parties** (clause 4). The organisation must determine what external and internal issues affect it and who has an interest in its performance — the authority, the neighbours, the customers, the workers. It is the clause that forces an organisation to look outside itself.
- **Compliance obligations** (clauses 6 and 9). The organisation must identify the legal requirements applicable to it and evaluate periodically whether it meets them, **with evidence**. This is where the whole of chapter 1 of this course becomes operational.
- **Documented information** (clause 7). The standards no longer prescribe a list of procedures: they require that the information necessary for the effectiveness of the system be documented, controlled and available. The judgement of what is necessary belongs to the organisation, and it must be able to justify it.

2.6 Exercises — chapter 2

Exercise 2.1. Explain why consensus, and not unanimity, is the decision rule of standardisation. What would be the consequence of requiring unanimity?

Exercise 2.2. A laboratory holds a certificate stating that its management system meets ISO 31000. Comment.

Exercise 2.3. Distinguish, with one sentence each and one example each, the missions of IANOR, ALGERAC, ONML and INAPI.

Chapter 3 — Standardisation of production

Four weeks. This chapter is the most technical of the course and the one most directly useful in a workshop.

3.1 Normative parameters and interchangeability

No manufacturing process produces an exact dimension. A shaft nominally 40 mm in diameter will be, in reality, 39.987 mm or 40.004 mm. Since exactness is impossible, the designer does not prescribe a dimension: **he prescribes an interval within which the dimension must fall**. That interval is the tolerance, and interchangeability is the direct consequence of tolerancing.

The vocabulary, fixed once and for all

Term	Definition
Basic size (nominal)	The theoretical dimension from which the limits are derived — 40 mm in the example
Limits of size	The maximum and minimum permissible dimensions
Tolerance	The difference between the upper limit and the lower limit. It is always positive, and it has no sign
Deviation	The algebraic difference between a limit and the basic size. It has a sign
Zero line	The line representing the basic size in a graphical representation
Fit	The relationship resulting from the difference, before assembly, between the sizes of a hole and a shaft that are to be assembled

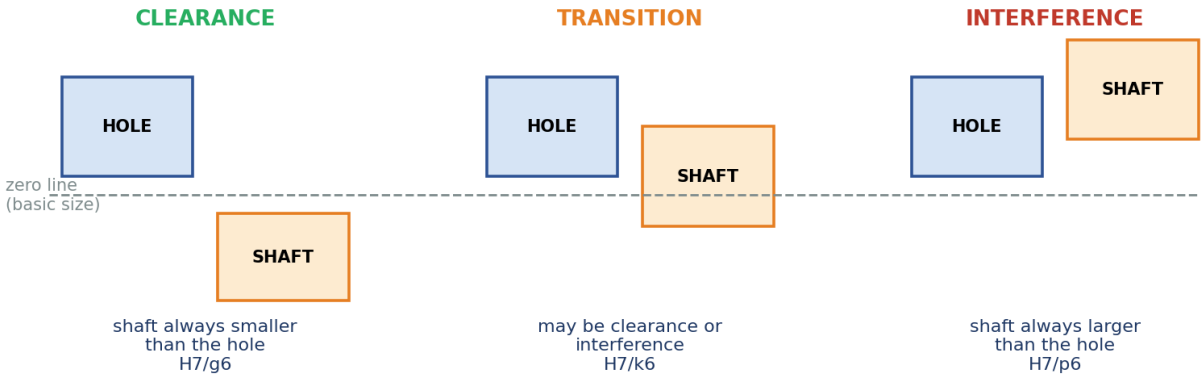
The ISO system of limits and fits

The international system, ISO 286, designates a tolerance by **a letter and a number**. The number, called the **tolerance grade IT**, fixes the width of the interval: IT01 is the finest, IT18 the coarsest, and the width increases with the basic size — a tolerance of one hundredth of a millimetre is severe on a 10 mm shaft and impossible on a 500 mm one. The letter fixes the **position** of the interval relative to the zero line: capital letters for holes, lower-case letters for shafts.

Hence a designation such as **⌀40 H7** — a hole of basic size 40, position H, grade 7 — or **⌀40 g6** for the corresponding shaft. Written together, **⌀40 H7/g6** designates the fit.

The three classes of fit

Figure 2.4 — The three classes of fit (hole-basis system, ISO 286)



Tolerance = upper limit − lower limit. The IT grade fixes its width (IT01 to IT18); the letter fixes its position relative to the zero line (capital for holes, lower case for shafts).

Class	Condition	Use
Clearance fit	The shaft is always smaller than the hole; there is always play	Parts that must slide or rotate: a shaft in a plain bearing, H7/g6
Transition fit	Depending on the actual sizes obtained, there may be play or interference	Accurate location with occasional dismantling: a gear on a shaft, H7/k6
Interference fit	The shaft is always larger than the hole; assembly requires force, heating or cooling	Permanent assemblies transmitting torque: a bearing ring, H7/p6

Why the hole-basis system is the usual choice. It is easier and cheaper to vary the diameter of a shaft, which is turned, than that of a hole, which is bored or reamed with a tool of fixed size. So one fixes the hole at H and varies the shaft letter to obtain the desired fit. This is a manufacturing reason, not a theoretical one, and it is the kind of reasoning the examination rewards.

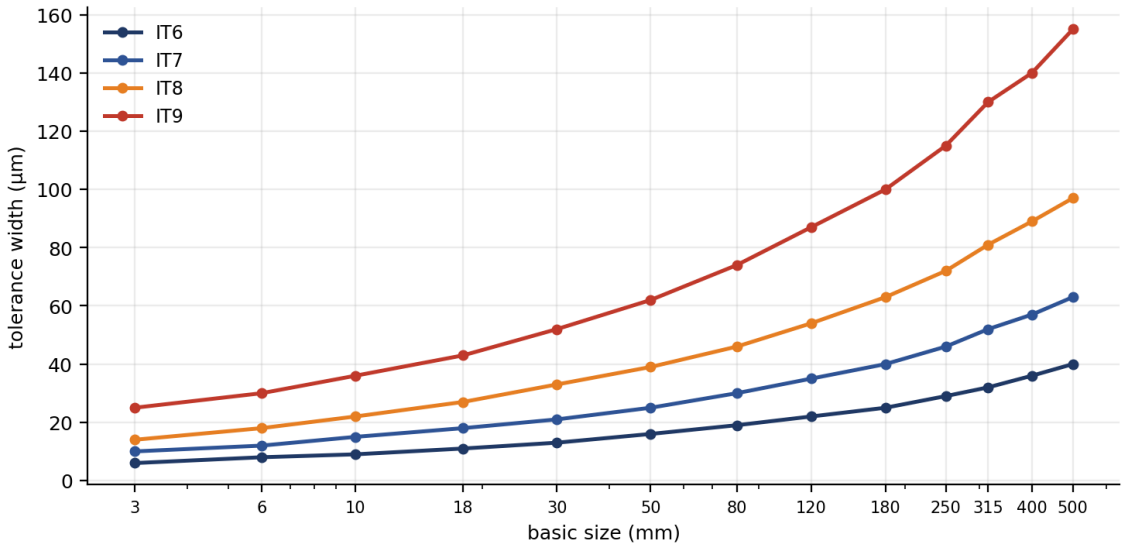
Worked example

A shaft is to rotate freely in a bearing bush, basic size 40 mm. The designer specifies **⌀40 H7/g6**. The hole H7 has its lower deviation at zero: its interval runs from 40.000 mm upwards. The shaft g6 has a small negative upper deviation: its whole interval lies below the zero line. Therefore, whatever the actual parts, **the shaft is always smaller than the hole**: there is always clearance and the assembly always turns. The workshop can produce shafts and bushes independently, in different places, and any shaft will fit any bush. That property — and not the precision of any individual part — is interchangeability.

3.2 IT grades: a numerical example, and how the tables are used

The letter fixes the position of the tolerance interval, the number fixes its width. That width is not a fixed quantity: it grows with the basic size, because a given manufacturing process holds a relative and not an absolute precision.

Figure 2.10 — Tolerance width grows with the size, for a given IT grade
Indicative values; always read the actual table of ISO 286



What the grades correspond to, in practice

Grades	Typical achievement	Where they are used
IT01 to IT4	Lapping, honing, fine grinding	Gauges, measuring instruments, high-precision bearings
IT5 to IT7	Grinding, fine turning, reaming	**The usual range of mechanical fits**: shafts, bores, bearing seats
IT8 to IT11	Turning, milling, drilling, broaching	Ordinary machined parts, non-critical assemblies
IT12 to IT18	Casting, forging, rolling, cutting	Raw or semi-finished dimensions, free dimensions

Worked example

> A shaft of basic size 40 mm is specified **⌀40 g6** and its housing **⌀40 H7**. From the tables of ISO 286, for the size interval above 30 and up to 50 mm: H7 gives a width of 25 µm and, since H places the lower deviation at zero, the hole runs from **40.000 to 40.025 mm**. g6 gives a width of 16 µm with an upper deviation of −9 µm, so the shaft runs from **39.975 to 39.991 mm**. **Minimum clearance** = 40.000 − 39.991 = **0.009 mm**. **Maximum clearance** = 40.025 − 39.975 = **0.050 mm**. The assembly therefore always turns, with a play between 9 and 50 micrometres, whichever shaft meets whichever bore. *The numerical values are indicative and must be read in the current table; the reasoning is what is examinable.*

Two things to notice. The clearance is never zero, which is what guarantees assembly without selection or adjustment. And the range of clearance — from 9 to 50 µm — is the price of interchangeability: a fitted assembly would give a constant play but would require pairing each shaft with its bore, which destroys the whole benefit.

3.3 Surface texture and geometrical specification

A dimensional tolerance controls a size. It controls neither the **shape** of the surface nor its **roughness**, and a part may be within its dimensional tolerance and still be unusable.

Surface texture

The most used parameter is **Ra**, the arithmetic mean deviation of the profile from its mean line, expressed in micrometres. Typical orders of magnitude: 12.5 µm for rough turning, 3.2 µm for ordinary turning, 1.6 µm for

fine turning, 0.8 µm for grinding, 0.2 µm and below for lapping. Roughness matters wherever a surface must seal, slide, resist fatigue or be coated — and it costs: each step down the scale multiplies the machining time.

> **A rule of design worth stating.** Specifying a finer roughness or a tighter tolerance than the function requires is the most common and least visible way of making a part expensive. The correct question is never *how precise can we make it* but *how precise must it be, and why*.

Geometrical product specification

Geometrical tolerancing controls the deviations of form, orientation, location and run-out that dimensions cannot express. Four families are distinguished, and knowing that they exist is enough at this level.

Family	Examples	What it controls
Form	Straightness, flatness, roundness, cylindricity	The shape of a single feature, referred to nothing else
Orientation	Parallelism, perpendicularity, angularity	The attitude of a feature relative to a datum
Location	Position, concentricity, symmetry	Where a feature is, relative to datums
Run-out	Circular and total run-out	The combined effect of form and location during rotation

All of these refer to **datums**, which are the reference features chosen by the designer, and the choice of datums is a functional decision: they should be the surfaces by which the part is actually located in service, not the surfaces that are convenient to measure.

3.4 Statistical control and process capability

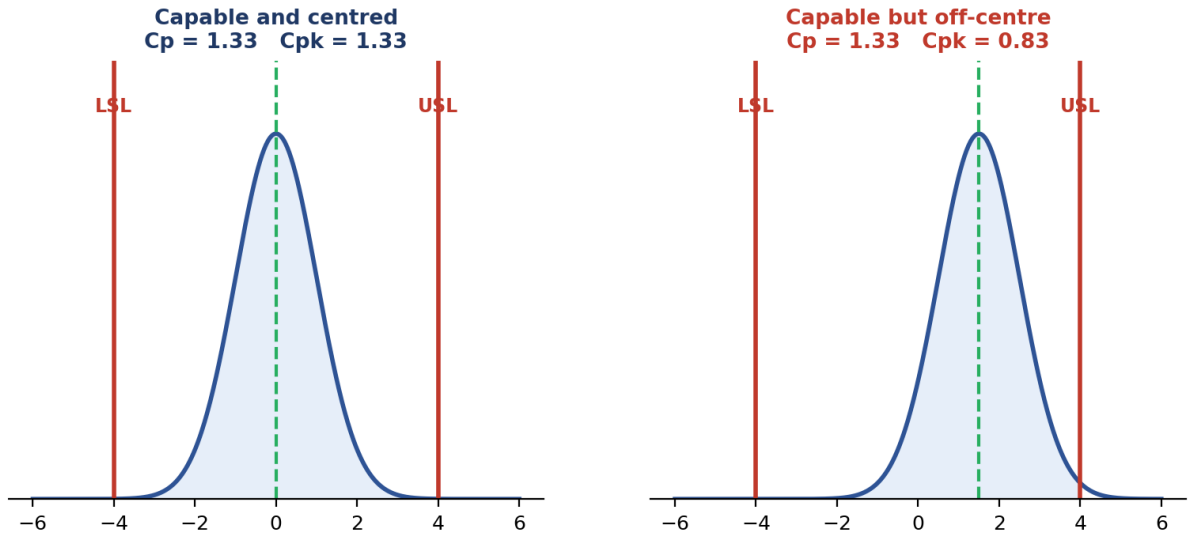
A tolerance defines what is acceptable. It does not say whether the process is able to produce within it, nor whether it will still be able tomorrow. Those two questions are answered by capability and by control, and they are the modern form of conformity control: **one no longer inspects the parts, one controls the process that makes them**.

The two capability indices

Let USL and LSL be the upper and lower specification limits, σ the standard deviation of the process and µ its mean.

> **$C_p = (USL - LSL) / 6\sigma$** measures only the **spread**: it compares the width of the tolerance with the natural width of the process. **$C_{pk} = \min[(USL - \mu), (\mu - LSL)] / 3\sigma$** measures the spread **and the centring**: it looks at the nearer limit only. $C_p = C_{pk}$ when the process is exactly centred. C_{pk} is always the smaller of the two.

Figure 2.11 — Process capability: Cp measures the spread, Cpk measures spread and centring



The same spread gives the same Cp. Only Cpk detects that the right-hand process is drifting towards the upper limit.

The two distributions above have the **same spread**, therefore the same Cp of 1.33. The right-hand one has drifted towards the upper limit, and its Cpk falls to 0.83. A control based on Cp alone would declare both processes capable; only Cpk detects that the second is producing scrap at the upper limit. **This is why Cp alone is never sufficient**, and it is the point most frequently examined.

The values usually required

Value of Cpk	Interpretation	What is done
< 1.00	Not capable	Non-conforming parts are being produced. Stop and correct the process, not the inspection
1.00 to 1.33	Marginal	Capable in principle but with no margin. Any drift produces defects. Reinforce the control
≥ 1.33	Capable	Commonly required in a supply contract
≥ 1.67	Highly capable	Required for critical characteristics, safety-related or regulated

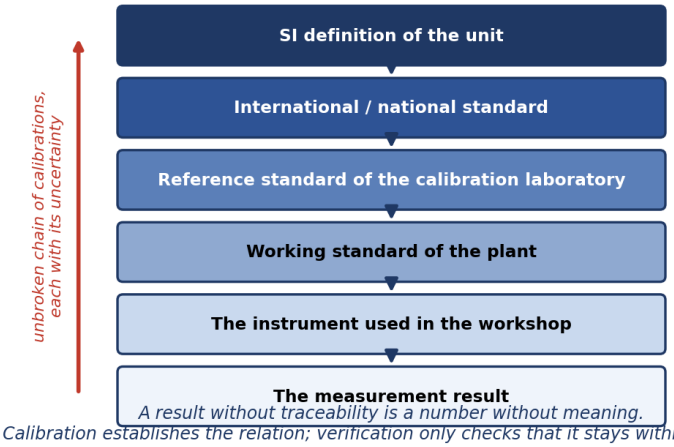
Control charts

A control chart plots a statistic — usually the mean and the range of small samples — against time, with **control limits** computed from the process itself, not from the tolerance. This distinction is essential and constantly confused: **the specification limits say what the customer accepts, the control limits say what the process normally does**. A point outside the control limits signals that something has changed, even if the part is still within tolerance — and that is the whole point: it warns before the defect appears.

3.5 Metrology: what makes a measurement mean something

Every statement in this chapter rests on measurements. A measurement that cannot be related to a common reference is a private number, and comparing two such numbers is meaningless.

Figure 2.12 — Metrological traceability



Calibration establishes the relation; verification only checks that it stays within tolerance.

Metrological traceability is the property of a result whereby it can be related to a reference through an unbroken chain of calibrations, **each contributing to the measurement uncertainty**. The chain runs from the definition of the unit in the international system down to the caliper in the workshop, and a break anywhere in it invalidates everything below.

Three distinctions to hold firmly

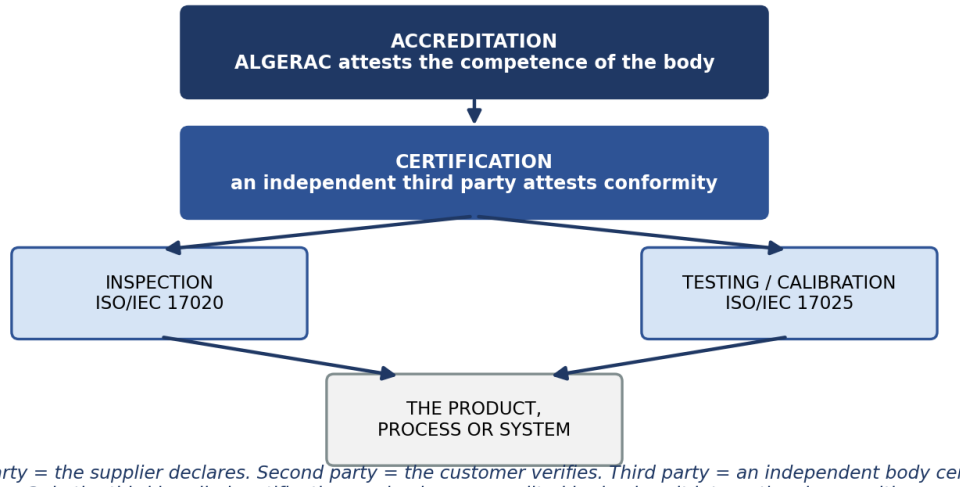
Terms	Difference	Consequence
Calibration vs **verification**	Calibration establishes the relation between the indication and the reference value, with its uncertainty. Verification only confirms that the instrument stays within specified tolerances	A verified instrument is fit for use; only a calibrated one lets you correct a reading
Accuracy vs **precision**	Accuracy is closeness to the true value. Precision is closeness of repeated measurements to each other	An instrument may be precise and consistently wrong — the most dangerous case, because it inspires confidence
Error vs **uncertainty**	Error is a difference from the true value, unknowable. Uncertainty is the interval within which the value is believed to lie	A result is written as *value ± uncertainty*, and a result without uncertainty is incomplete

> **Where this touches conformity directly.** When a measured value falls very close to a limit, the uncertainty decides whether conformity can be declared. A result of 99 mg/L against a limit of 100 mg/L, with an uncertainty of ±5, does **not** demonstrate conformity: it demonstrates that the true value lies between 94 and 104. Rules of decision must therefore be agreed in advance, and this is one of the requirements of ISO/IEC 17025 on testing laboratories.

3.6 Methods of conformity control and certification

Specifying a characteristic is useless if no one verifies it. Conformity assessment is the set of activities that establish whether the requirements are fulfilled, and its whole difficulty is a question of **who says so, and why should we believe him**.

Figure 2.5 — Conformity assessment: who attests what, and who attests the attester



First party = the supplier declares. Second party = the customer verifies. Third party = an independent body certifies. Only the third is called certification, and only an accredited body gives it international recognition.

The three parties

Party	Who attests	Value of the attestation
First party	The supplier himself — *supplier's declaration of conformity*	Legally meaningful, engages his liability, but rests on his own word
Second party	The customer, or someone on his behalf — reception inspection, supplier audit	Strong for the parties, worthless for a third
Third party	An independent certification body	The only one that can be presented to anyone: the body has no interest in the outcome

The operations

- **Sampling** — how the items examined are drawn from the batch. A control plan states the sample size and the acceptance criterion; a conclusion drawn from a sample chosen by the supplier is not a control.
- **Testing** — measurement of a characteristic in a laboratory, under an agreed method. Accreditation to **ISO/IEC 17025** attests the laboratory's technical competence.
- **Inspection** — examination of a product, process or installation, generally by observation and simple measurement. Accreditation to **ISO/IEC 17020**.
- **Certification** — third-party attestation, for a product (**ISO/IEC 17065**) or for a management system (**ISO/IEC 17021-1**), usually renewed by periodic surveillance.
- **Accreditation** — attestation by an authoritative body that a conformity assessment body is competent. In Algeria this is ALGERAC. Accreditation is what makes a certificate recognised beyond the borders, through the mutual recognition arrangements between accreditation bodies.

> **The chain that must be understood.** A certificate is worth what the certifier is worth; the certifier is worth what his accreditation is worth; the accreditation is worth what the international recognition of the accreditation body is worth. A certificate issued by a body accredited by nobody proves nothing, and such certificates are common. Ask, always: *accredited by whom, and for what scope?*

Marking

A conformity mark is a visible sign that a product has undergone a defined assessment. In Europe, **CE marking** attests conformity to the applicable directives — it is a regulatory mark, affixed by the

manufacturer, and it is not a quality label. In Algeria, conformity to national standards may be attested by the mark managed by IANOR. Confusing a regulatory mark with a voluntary quality mark is a classic error.

3.7 Exercises — chapter 3

Exercise 3.1. For ⌀25 H8/f7, state the class of fit and give one application. Explain your reasoning from the letters alone.

Exercise 3.2. Explain, in the language of tolerances, why a repair workshop can replace a bearing without adjusting it by hand, whereas a nineteenth-century workshop could not.

Exercise 3.3. A supplier presents a certificate of conformity to ISO 9001. List four questions you must ask before granting it any weight.

Exercise 3.4. Classify: (a) a test report from a plant laboratory; (b) a report from an ISO/IEC 17025 accredited laboratory; (c) a customer audit; (d) an ISO 45001 certificate. For each, say which party attests and what its value is towards a third.

Chapter 4 — Classification

Four weeks.

4.1 Classification of products

Before standardising, one must be able to designate. A classification is a systematic arrangement of objects into classes according to declared criteria, and its quality is judged on three properties: the classes must be **exhaustive**, so that every object finds a place; **mutually exclusive**, so that no object belongs to two classes; and the criterion must be **stated**, so that the arrangement can be reproduced by someone else.

Industry uses several classifications in parallel, and they do not coincide, because they were built for different purposes.

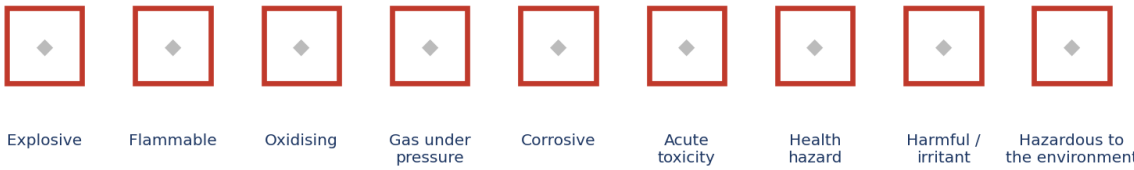
Classification	Purpose
Customs nomenclature (Harmonised System)	Levy duties and record trade. Groups by material and degree of processing
Statistical classification of activities	Describe the economy. Groups by the activity of the producer, not by the product
Classification of dangerous goods (UN numbers, classes of transport)	Manage transport risk. Groups by hazard: explosive, flammable, toxic, corrosive
Classification and labelling of chemicals (GHS)	Communicate hazard to the user. Hazard classes, categories, pictograms, hazard and precautionary statements
Classified installations	Subject an activity to authorisation or declaration according to the nuisance and hazard it presents

> **A remark that is worth more than the list.** The same drum of solvent belongs simultaneously to a customs heading, a transport class, a GHS hazard class and possibly a threshold of the classified-installation regime. These four classifications answer four different questions, and an engineer who mixes them will apply the wrong rule. Ask first: *for what purpose is this classification made?*

The classification of chemical hazards, and why it governs everything else

Among all the classifications of products, the one an HSE engineer meets daily is the classification of chemicals, because it commands the label, the safety data sheet, the storage rules, the transport rules and often the regime of the installation.

Figure 2.13 — The nine hazard pictograms of the GHS (shape and frame only)



A label carries: the pictogram, a signal word (DANGER or WARNING), hazard statements (H) and precautionary statements (P), the product identifier and the supplier. The safety data sheet develops all of it in sixteen sections.

The globally harmonised system classifies a substance in **hazard classes** — physical, health, environmental — each divided into **categories** by severity. From the classification follow, automatically and without discretion, the pictogram, the signal word, the hazard statements coded H and the precautionary statements coded P. **Classification is therefore not a description, it is a decision with legal effects.**

The same product, four classifications, four purposes

Question asked	Classification used	What it produces
What duty is payable?	Customs nomenclature	A tariff heading and a rate
How may it be carried?	Transport classes and UN numbers	Packaging, placarding, driver qualification, routing
How must it be labelled and stored?	GHS hazard classes	Pictograms, statements, incompatibilities, storage limits
Does the plant need an authorisation?	Nomenclature of classified installations	Declaration, registration or authorisation, and the thresholds

> **The error to avoid, and it is committed constantly.** A product not classified as dangerous for transport may still be classified as hazardous for health, and a quantity below the threshold of the classified-installation regime may still require full labelling and a safety data sheet. **Each classification answers its own question and none dispenses with the others.**

4.2 Classification and codification of standards

A national body publishes tens of thousands of standards. Without a classification they are unfindable, and an unfindable standard has no effect.

Reading a reference

Figure 2.6 — Anatomy of a standard reference

Examples: ISO 9001:2015 quality · ISO 14001:2015 environment · ISO 45001:2018 occupational health and safety
NA 1234 is an Algerian standard; EN, DIN, BS, ASTM designate other issuing bodies.

The reference names the **issuing body**, the **serial number** and the **year of the edition**. Prefixes tell you the origin at a glance: **ISO** and **IEC** international; **EN** European; **NA** Algerian; **NF** French; **DIN** German; **BS** British; **ASTM** and **ANSI** American. A composite prefix records an adoption: **NA EN ISO 9001** is the Algerian adoption of the European adoption of the international standard.

> **Always cite the year.** *ISO 9001* designates a family; *ISO 9001:2015* designates a document with a definite content. A contract that requires compliance with *ISO 9001* without a year is ambiguous, and ambiguity in a contract is resolved against the party who drafted it.

The International Classification for Standards

Figure 2.7 — Classification and codification of standards: the ICS

Extract from the International Classification for Standards (ICS)

13	Environment, health protection, safety
13.100	Occupational safety, industrial hygiene
13.110	Safety of machinery
13.200	Accident and disaster control
13.300	Protection against dangerous goods
13.340	Protective equipment

The ICS arranges standards by subject on three levels: **field**, **group**, **subgroup**. Field 13 covers environment, health protection and safety; group 13.100 covers occupational safety and industrial hygiene; subgroup 13.340.10 covers protective clothing. The catalogue of any standards body can be browsed by these codes, and this is the normal way to answer the question *which standards exist on this subject?*

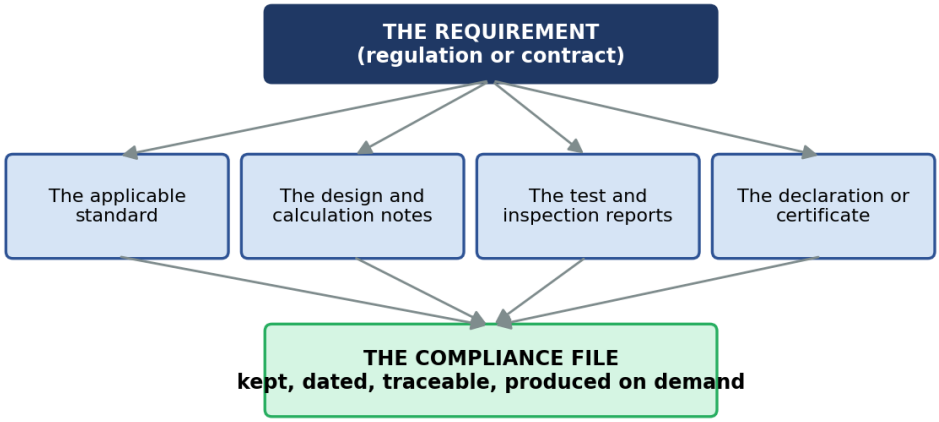
A method of search, to be used in practice

6. **State the object precisely.** Not *safety*, but *respiratory protective devices against particles*.
7. **Find the ICS code** of the corresponding subgroup, and list the standards it contains.
8. **Check the status** of each candidate: in force, revised, withdrawn. A withdrawn standard may still be used by agreement, but its use must be declared.
9. **Check the national adoption**, if a national reference is needed for a regulatory or contractual purpose.
10. **Read the scope clause first.** The scope tells you what the standard does and does not cover, and it is the clause that decides whether the standard is the right one.

4.3 Proving compliance: the file, and how it is built

The whole course converges here. Compliance is not a property of a product, it is a **demonstration**, and a demonstration is a set of documents that can be produced on the day an inspector, a customer or a judge asks for it.

Figure 2.14 — What proving compliance actually requires



Compliance is not a state, it is a file. What cannot be produced on the day of the inspection does not exist.

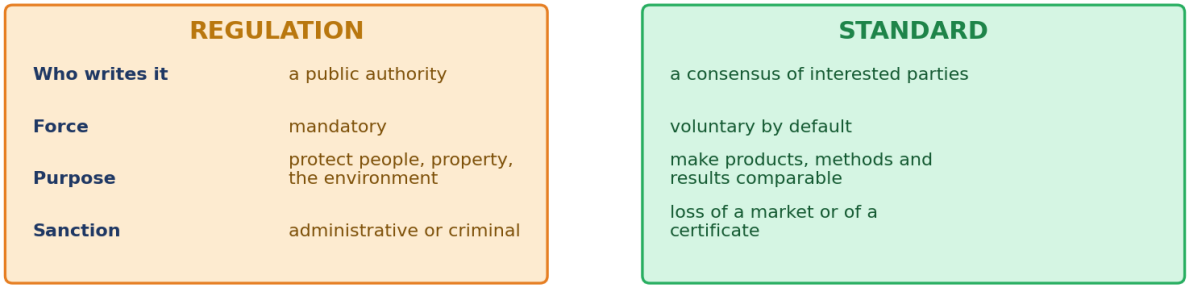
What the file contains, in order

11. **The requirement**, identified and dated: the article of the regulation, or the clause of the contract.
12. **The applicable standard**, with its year of edition, and the justification of why it is the right one — normally its scope clause.
13. **The design and calculation notes** showing how the requirement is met, signed and dated.
14. **The test and inspection reports**, from an identified laboratory, with the method used, the traceability of the instruments and the uncertainty.
15. **The declaration or the certificate**, and where a certificate is invoked, the accreditation of the body that issued it, with its scope.
16. **The record of modifications**: what changed, when, and what was re-verified as a result.

The rule that summarises the chapter, and probably the course. What cannot be produced on the day of the inspection does not exist. A test performed and not recorded, a calculation made and not kept, a certificate expired and not renewed — all are, from the point of view of the demonstration, identical to never having been done.

4.4 Regulation and standard: how they meet

Figure 2.8 — Regulation and standard: two different instruments



They meet when a regulation cites a standard: the standard then becomes mandatory for that purpose only. This is the mechanism of the European New Approach, and it is increasingly used in Algerian regulation.

The course closes on the mechanism announced at the beginning. A regulation states an **objective** — a machine shall not injure its operator, an effluent shall not exceed a limit. It does not say how to achieve it, because a regulation that prescribed a technique would freeze it and would be obsolete in ten years. The standard supplies the technique. When the regulation refers to the standard, conformity to the standard gives a **presumption of conformity** to the regulation: the manufacturer who follows it is presumed to meet the requirement, and the burden of proving otherwise falls on the authority.

This division of labour — the authority fixes the objective, the technical community fixes the means — is the basis of the European New Approach, and it is increasingly used elsewhere, including in Algerian regulation. It explains why an engineer must know both: **the regulation tells him what he must achieve, the standard tells him how it is done, and only the two together tell him whether he is compliant.**

4.5 Exercises — chapter 4

Exercise 4.1. Decompose the references NA EN ISO 14001:2015 and IEC 60079-10-1:2020, naming each element.

Exercise 4.2. Using the ICS structure of Figure 2.7, say in which field and group you would look for a standard on the sound level of machinery, and justify.

Exercise 4.3. A regulation requires that a pressure vessel be *designed so as to withstand the pressures to which it will be subjected*. Explain how a standard makes this requirement applicable, and what presumption of conformity means.

Exercise 2.4. A document bears the reference ISO/TR 12345:2021. A supplier writes that his product *complies with it*. What is wrong with that sentence?

Exercise 2.5. Explain why a country that is an O-member of a technical committee is in a weaker position than a P-member, using the argument of §1.3 on technical barriers to trade.

Exercise 3.5. A process produces a dimension with mean 20.04 mm and standard deviation 0.02 mm, against a specification of 20.00 ± 0.10 mm. Compute Cp and Cpk, and conclude.

Exercise 3.6. A laboratory reports 98 mg/L with an expanded uncertainty of ±4 mg/L, against a limit of 100 mg/L. May conformity be declared? Justify with §3.5.

Exercise 3.7. Explain the difference between a control limit and a specification limit, and say which of the two would warn you first that a tool is wearing.

Exercise 4.5. Build the list of documents that would constitute the compliance file of a pressure vessel bought from a foreign supplier, using §4.3.

Exercise 4.4. The same drum of xylene must be transported, stored, declared to customs and labelled. Name the classification used in each case and the question it answers.

Case study — putting the whole course to work

> **The situation.** A plant must install a new storage tank for a flammable solvent. The engineer is asked three questions by the management: is it allowed, what must it comply with, and how will we prove it? The case is treated with the instruments of the four chapters, in the order in which they are actually used.

Step 1 — Situate the requirement (chapter 1)

The first move is not technical, it is to establish **which texts apply and at what level**. The activity falls under the regime of classified installations, whose threshold depends on the quantity stored: below one threshold a declaration suffices, above it an authorisation with an impact study and a hazard study is required. The quantity is therefore not a design parameter only, it is a **legal parameter**, and choosing 45 m^3 rather than 55 m^3 may change the whole procedure.

At the same level, the general prescriptions on occupational hygiene and safety apply to the workplace created, and the environmental law applies to the discharges and to the bunding. **Three families of text, one installation.**

Step 2 — Find the technical means (chapters 2 and 4)

The regulation says the tank shall be designed so as to prevent leakage and to contain a spill. It does not say how. The standards say how: standards on the design of atmospheric storage tanks, on bunding, on electrical equipment for explosive atmospheres, on earthing and bonding, on venting. **They are found through the ICS**, verified for status and edition, and their scope clauses are read before use.

The classification of the solvent, by the GHS, gives the pictograms, the incompatibilities and hence the separation from other stored products; its transport classification governs the deliveries; its flash point and explosive limits, read in the safety data sheet, govern the electrical zoning.

Step 3 — Specify the production (chapter 3)

The tank is procured from a supplier. The specification must state the plate thickness with its tolerance, the surface preparation before coating with its roughness parameter, the tolerances on the nozzle positions, the welding qualification, and the tests: dimensional inspection, non-destructive testing of welds, hydrostatic test. **Each requirement is written with a method and an acceptance criterion**, otherwise it is not verifiable and will be argued about at reception.

The instruments used at reception — thickness gauge, pressure gauge — must be **calibrated and traceable**, and the decision rule near the limits agreed in advance. Where a characteristic is produced in series, such as the welds, capability rather than piece inspection is the modern requirement.

Step 4 — Build the proof (chapter 4)

Element of the file	Content in this case
The requirement	The article of the classified-installation regulation, and the clause of the purchase contract
The applicable standards	Design, bunding, zoning, venting — each with its year and its scope justification
Design and calculation	Thickness calculation, bund volume, vent sizing, zoning plan, signed and dated
Tests and inspections	Weld examination reports, hydrostatic test report, earthing measurement, with instrument traceability

Element of the file	Content in this case
Declaration or certificate	Supplier declaration of conformity; where equipment for explosive atmospheres is used, the certificates of the equipment with the accreditation of the issuing body
Modifications	Any change during erection, and what was re-verified as a result

What the case demonstrates, and it is the conclusion of the course. Not one of the four chapters was sufficient alone. The regulation said what had to be achieved and nothing about how; the standards said how and nothing about whether it was compulsory; the tolerances and the metrology made the requirements verifiable; and the classification decided which regime applied in the first place. **An engineer who knows only one of the four cannot answer any of the three questions the management asked.**

Solutions to selected exercises

Exercise 1.1

(a) Law: mandatory for all. (b) ISO 45001: a standard, **voluntary**, unless a contract or a regulation imposes it. (c) Ministerial order: mandatory, within its scope. (d) Internal procedure: mandatory inside the organisation only, by the employer's authority. (e) A standard cited by name in a contract: **mandatory between the parties**, by the effect of the contract and not of the law. Case (e) is the one that shows that *voluntary* means voluntary by default, not voluntary always.

Exercise 1.2

Which standard, with its year of edition — a family reference proves nothing. **Which clauses**, since a product may meet part of a standard only. **On what evidence**: a supplier's declaration, a customer inspection or a third-party certificate, and if a certificate, issued by a body accredited by whom and for what scope.

Exercise 2.2

ISO 31000 is a **guidance** standard: it contains recommendations and no requirements, therefore there is nothing to audit conformity against. No accredited body can certify a system against it. A certificate purporting to do so is either a misunderstanding or a commercial device, and it has no value towards a third party.

Exercise 2.4

A technical report is **informative**: it contains data or a state of the art and no requirement. There is nothing to comply with. The correct formulation would be that the product was designed *taking into account* the report, or that the report was used as a source.

Exercise 3.1

⌀25 H8/f7. H places the hole with its lower deviation at zero; **f** is a shaft letter well below the zero line, further from it than g. Therefore the shaft is always smaller than the hole: **clearance fit**, and a wider clearance than H7/g6. Typical use: a rotating shaft in a plain bearing with generous lubrication, or a sliding assembly where accuracy of location is not required.

Exercise 3.5

USL = 20.10, LSL = 19.90, so the tolerance width is 0.20 mm. Cp = 0.20 / (6 × 0.02) = **1.67**: the spread is excellent. For Cpk, the nearer limit is the upper one: (20.10 − 20.04) / (3 × 0.02) = 0.06 / 0.06 = **1.00**. The process is **capable in spread but off-centre**, and Cpk of 1.00 leaves no margin. **The correction is free**: recentre the process by adjusting the setting by 0.04 mm, and Cpk rises to 1.67 without touching the machine's precision. This is precisely why Cp alone is misleading.

Exercise 3.6

The result is 98 ± 4, so the true value lies between 94 and 102 mg/L, and part of that interval exceeds the limit of 100. **Conformity cannot be declared** with the usual convention requiring the whole interval to lie below the limit. Three ways out: reduce the uncertainty by a better method, agree a decision rule in advance with the customer or the authority, or — the honest answer — report the result with its uncertainty and let the decision rule apply.

Exercise 3.7

The **specification limit** comes from the design and says what the customer accepts. The **control limit** is computed from the process itself and says what the process normally does; it is usually much narrower. A wearing tool produces a slow drift of the mean, which crosses the control limit **long before** any part crosses the specification limit. The control chart therefore warns first, and that is its purpose: to detect a change while the product is still good.

Glossary — English, French, Arabic

English	Français	العربية
Standard	Norme	مواصفة قياسية
Regulation	Réglementation	تنظيم
Law	Loi	قانون
Executive decree	Décret exécutif	مرسوم تنفيذي
Standardisation	Normalisation	التقييس
Consensus	Consensus	توافق
Conformity	Conformité	مطابقة
Certification	Certification	إصدار الشهادات
Accreditation	Accréditation	الاعتماد
Testing laboratory	Laboratoire d’essais	مخبر التجارب
Inspection	Inspection	التفتيش
Interchangeability	Interchangeabilité	قابلية التبادل
Tolerance	Tolérance	التفاوت
Fit	Ajustement	التوافق
Clearance	Jeu	خلوص
Interference	Serrage	تداخل
Basic size	Cote nominale	المقاس الاسمي
Legal metrology	Métrologie légale	القياسة القانونية
Presumption of conformity	Présomption de conformité	قرينة المطابقة

Assessment and study advice

Assessment: final written examination, 100 % of the mark. Expect one question placing texts in the hierarchy of norms, one on the bodies and their missions — where IANOR and INAPI must not be confused — one reading or construction of a fit designation, and one on conformity assessment and the value of a certificate.

Three pieces of advice. First, learn the four Algerian bodies of §2.2 by their mission and not by their acronym; the examination asks what they do. Second, in any question on tolerances, reason from the letters and the position relative to the zero line before touching a table of values: the class of fit is decided by position, not by arithmetic. Third, whenever you write that something is *mandatory*, say for whom and by virtue of what text — the distinction between mandatory and voluntary is the backbone of this course.

Appendix — Four tools for practice

A.1 How to find the standard applicable to a subject

17. State the object in technical terms, as narrowly as possible.
18. Identify the ICS field and group, and list the standards of the subgroup.
19. Read the **scope clause** of each candidate before anything else — it says what the standard covers and, more usefully, what it excludes.
20. Check the status: in force, under revision, withdrawn and replaced by which.
21. Check whether a national adoption exists, and whether it is identical or modified.
22. Note the reference **with its year** and keep it in the file.

A.2 How to read a certificate presented by a supplier

Look at	And ask
The **scope**	Does it cover the product and the site actually supplying you, or another site of the same group?
The **standard and its year**	Is it the edition in force? A certificate against a superseded edition expires with it
The **issuing body**	Is it accredited, by which accreditation body, and is that body party to an international recognition arrangement?
The **validity dates**	Is it current, and have the surveillance audits been carried out?
The **certificate number**	Can it be verified in the register of the certification body? Most publish one

A.3 The vocabulary that must never be confused

Do not say	Say
Norme for a regulation	A standard is voluntary by default; a regulation is mandatory
Certified for a declared conformity	Certification is by a third party; the supplier *declares*
Accredited for *certified*	A laboratory is accredited; a management system is certified
ISO 9001 without a year	ISO 9001:2015 — the year is part of the reference
Calibrated for *verified*	Calibration gives the relation and its uncertainty; verification only checks a tolerance
INAPI for the standards body	IANOR is the national standards body; INAPI deals with industrial property

A.4 A checklist before signing a technical specification

- Is every requirement **verifiable**, that is, is there a method and an acceptance criterion?
- Is every standard cited **with its year** and is that edition in force?
- Are the tolerances justified by the function, or copied from a previous drawing?
- Who performs the tests, and must the laboratory be accredited?
- What decision rule applies when a result falls within the uncertainty of a limit?
- What documents must the supplier deliver, and when — before, with, or after the goods?

References

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- Chevalier, A. *Guide du dessinateur industriel.* Hachette Technique — for tolerances, fits and their tables.

Legal references are given for orientation. Always consult the version in force before using them in a professional document.

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