OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

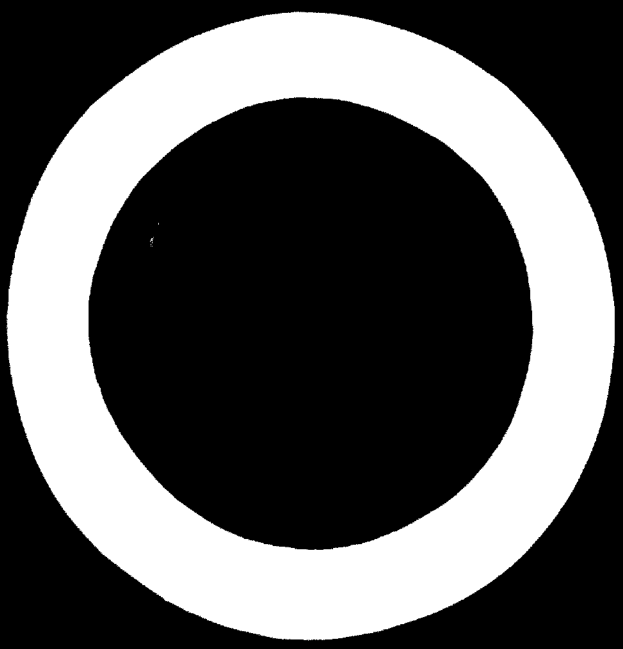
For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

02322

THE INTERRELATIONSHIP BETWEEN PARAMETERS OF THE LEATHER INDUSTRY

UNITED NATIONS



THE INTERRELATIONSHIP BETWEEN PARAMETERS OF THE LEATHER INDUSTRY

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
VIENNA

THE INTERRELATIONSHIP BETWEEN PARAMETERS OF THE LEATHER INDUSTRY

UNITED NATIONS
New York, 1973

ID/99
(ID/WG. 79/6/Rev. 1)

UNITED NATIONS PUBLICATION
Sales No.: E.73.II.B.2
Price: $ U.S. 1.00 (or equivalent in other currencies)

PREFACE

This study, which has been prepared for UNIDO by J. A. Villa, director, Ediciones Cuerecon, S. R. L., Buenos Aires, Argentina, presents a novel method of evaluating the productive capacity, general technological characteristics and dimensions of industrial tanneries. The method may be used to measure the efficiency of one tannery against another, or to forecast the requirements of a new one.

The author first draws up an inventory of the industrial characteristics of a tannery, from which he establishes a set of 24 parameters. Thirty-two "key coefficients" are then obtained by interrelating these parameters.

This methodological approach may be employed to study any size of existing or projected tannery using cattle hides as its raw material. Values quoted are averages prevailing in the Argentine tanning industry; needless to say, adjustments will have to be made to take into account the conditions prevailing in any other country to which the method is applied.

The views and opinions expressed in this publication are those of the author and do not necessarily reflect the views of the secretariat of UNIDO.

CONTENTS

INTRODUCTION

The purpose of this study is to offer a series of numerical coefficients to indicate the dimensions of a tannery from an industrial point of view, its productive capacity and its general technological characteristics.

The first step is to draw up an inventory of the industrial characteristics, and for this purpose a set of 24 parameters (4 production, 10 structure, and 10 input) is established:

Production parameters

m^2	square metres of tanned leather
ft^2	square feet of tanned leather
hides	number of tanned hides
kg	kilograms of raw hides processed

Structure parameters

m^2 FS	floor space, in square metres
HPi	horsepower installed
personnel	number of persons employed
workers	number of manual workers employed
litres of drums	total capacity of drums installed, in litres
machines	number of machines installed
kg mach.	weight in kilograms of the machines installed
kVA	kilovolt-amperes of the generator units
m^2 boil.	heating area of boilers in square metres
HP compr.	total horsepower of compressors

Input parameters

m-h	man-hours
w-h	worker-hours
kg ch	kilograms of chemicals
kg bch	kilograms of beamhouse chemicals
kg tch	kilograms of tanning chemicals
kg fch	kilograms of finishing chemicals
litres	litres of water
kg fuel	kilograms of fuel
theor. kWh	theoretical kilowatt-hours
act. kWh	actual kilowatt-hours

In a well-balanced tannery, these 24 parameters are generally as follows, in descending order of magnitude:

1. *Litres of water.* The total quantity of water consumed by the tannery in one year.

2. *Square feet.* The area of tanned leather produced in one year. This area is obtained by using numerical coefficients that show the quantities, in square feet, of each type of product turned out by the tannery. The transformation coefficients are given in the last chapter of this study.

3. *Kilograms.* Kilograms of raw hides put in water in one year.

4. *Theoretical kWh.* This is the only theoretical parameter in the series. It represents the number of kilowatt hours of electricity that would be consumed by the tannery in one year if all its machines were working simultaneously.

5. *Kilograms of chemicals.* The total quantity of chemicals consumed in one year.

6. *Actual kWh.* The kilowatt hours of electricity actually consumed in one year.

7. *Kilograms of tanning chemicals.* This represents the quantity of chemicals consumed in one year by operations subsequent to the beamhouse and prior to finishing that is to say, in pickling, tanning, neutralizing, retanning, fatliquoring, etc.

8. *Kilograms of fuel.* The amount of fuel used in one year to feed the boilers and other heat-generating units. This does not include the fuel used for generators, general transport vehicles, or for any other purpose.

9. *Square metres of tanned leather.* The area of tanned leather produced in one year. This area is obtained by using numerical coefficients that show the quantities, in square metres, of each type of product turned out by the tannery.

10. *Kilograms of beamhouse chemicals.* That quantity of chemicals used specifically in beamhouse operations in one year.

11. *Man-hours.* The combined total of hours worked in one year by all the persons employed in the establishment, namely workers and technical, administrative and management personnel. Salesmen are not included.

12. *Litres of drums.* This is the total capacity of all the drums in the tannery, with the exception of small testing drums. Beamhouses are usually equipped with drums, but in the case of a beamhouse using paddle vats the capacity of these should be computed as if they were drums. The capacity is measured in litres rather than cubic metres to facilitate calculation.

13. *Kilograms of machines.* The total weight in kilograms of all the production machines in the plant, irrespective of the material they are made of. Maintenance and repair machinery and machinery for general services (boilers, pumping engines etc.) are not included.

14. *Worker-hours.* The total number of man-hours worked in a year by manual workers, whether they are occupied directly in production or employed in general services, maintenance etc.

15. *Hides.* The number of hides processed in one year.

16. *Kilograms of finishing chemicals.* The total quantity of chemicals consumed in one year in the finishing operations.

17. *Floor space in square metres.* The total area covered by the plant buildings, including storage sheds, administration offices, boiler rooms etc.

18. *HP installed.* The combined horsepower of all production machinery. This category does not include machinery such as machine shop equipment, pumping engines etc.

19. *Kilovolt-amperes.* The total kVA of the plant's generator units.

20. *Square metres of boilers.* The heating area of the plant's boilers, in square metres.

21. *Personnel.* The total number of persons employed in the tannery, including manual workers as well as administrative, technical and managerial personnel but exclusive of salesmen.

22. *Workers.* The total number of manual workers employed in the tannery, in all operations.

23. *HP of compressors.* The total horsepower of the tannery's compressors.

24. *Machines.* The number of machines engaged in direct production.

Of these 24 parameters:

Only one is theoretical (theor. kWh);

Two are alternatives (m^2 and ft^2) since they depend on the unit of measurement being used;

One presents practical problems in its application and analysis (kg mach.) but it is recommended as it enables useful conclusions to be drawn;

Four refer to one subject (kg ch and its three derived parameters—kg bch, kg tch, and kg fch) and although numerical values have been given for them it should be understood that they are highly variable and, depending upon the case, may easily go outside the limits that have been fixed.

Combinations of the 24 parameters chosen provide a whole series of "guide numbers". These are set out in tables 3 and 4 (at the end of this study) which show all the possible combinations of parameters—that is to say, all the possible coefficients and their reciprocals.

$$\text{Example: } \frac{\text{HPi}}{\text{m}^2\,\text{FS}} \text{ and its reciprocal } \frac{\text{m}^2\,\text{FS}}{\text{HPi}}$$

Reciprocal coefficients giving values that are difficult to work with, that involve many decimal figures, or that are unrepresentative and give no useful information have been eliminated from the tables. The coefficients given apply in all cases to the average tannery.

Coefficients for four sizes of hides have been given:

Large hides: tanned hides of more than 3 m^2 in area;

Medium-sized hides: tanned hides of between 1.5 and 3 m^2 in area;

Small hides: tanned hides of between 0.6 and 1.5 m^2 in area;

Very small hides: tanned hides of less than 0.6 m^2 (generally between 0.2 and 0.6 m^2) in area.

The examples given in tables 3 and 4 are for large and small hides respectively. The example in table 3 is the most important, since in most countries large hides are processed in considerably greater quantities than other sizes.

Medium-sized hides are also important. Hides of Argentine heifers, which are widely used, usually fall into this category.

I. KEY COEFFICIENTS

Not all of the many possible combinations of parameters selected are representative. A large number are unnecessary. Many, on the other hand, are of key significance in any plant analysis. The values for three sizes of hides—large, small and very small—are given as the first set of key coefficients. However, it will be seen later that there are many others of equal or greater importance. While it would be normal for the values for medium-sized hides to be situated between those for large and small hides, many cases have been encountered in which the coefficients for the medium-sized hides fall outside this frame. This anomaly, for which a satisfactory explanation has not yet been found, makes it necessary to apply the following principle: in case of doubt, use values as close as possible to those given for large hides.

Coefficient 1: Productivity of workers and Productivity per man employed

$$\frac{ft^2}{w\text{-}h} \qquad\qquad \frac{ft^2}{m\text{-}h}$$

This is the best known guide number and that most widely used throughout the world. The custom of measuring the efficiency of a tannery in terms of the square feet produced by each manual worker and each employee of the establishment is almost universal.

This coefficient, however, gives a very limited picture of the tannery. A real diagnosis is given only by the totality of relevant coefficients. Difficulties arise when making a comparison between one tannery and another as each tanner uses his own personal judgement in making the calculation. Some take direct production workers only into account in calculating worker-hours, thereby obtaining a very high productivity coefficient which gives a false idea of the way the enterprise is actually operating. Others count direct production labour plus workers engaged in auxiliary operations. Yet a third group adds those responsible for general services: that is to say, direct plus indirect labour. A tannery also employs a large number of administrative and office workers, and various categories of technicians, whose man-hours must be computed since their remuneration represents an expense over and above the wages of manual workers.

The relationship between manual workers and total personnel in a well-balanced tannery is:

$$\frac{\text{workers}}{\text{total personnel}} = \text{from } 0.70 \text{ to } 0.75$$

The following method of calculating a coefficient that will standardize information and facilitate comparison between one tannery and another or the tanning industry of one country with that of others is recommended:

Only two types of measurement are used:

Worker-hours. The worker-hours for all the manual workers at the plant—that is to say, direct plus indirect labour.

Man-hours. The man-hours for all personnel employed in one way or another in the tannery. Only salesmen, who generally work on a contract or commission basis, are excluded.

The average for a tannery processing large hides is, in practice:

$$\frac{ft^2}{m\text{-}h} = 17 \qquad \frac{ft^2}{w\text{-}h} = 22 \text{ or } 23$$

The most important coefficient is probably that for over-all productivity, namely $\frac{ft^2}{m\text{-}h}$, which gives the truest idea of labour productivity. The other coefficient may encourage false optimism.

The coefficient for small hides is:

$$\frac{ft^2}{m\text{-}h} = 14 \qquad \frac{ft^2}{w\text{-}h} = 19 \text{ or } 20$$

That for very small hides is:

$$\frac{ft^2}{m\text{-}h} = 10 \qquad \frac{ft^2}{w\text{-}h} = 13$$

Coefficient 2: Yield in terms of floor space

$$\frac{ft^2}{m^2\,FS}$$

This coefficient gives an idea of the yield in terms of buildings. It tells the tanner whether his floor space is unutilized or poorly utilized or whether, on the other hand, his space is unduly limited and expansion is required.

The average value for large hides is 900, though in efficient tanneries it may be 1,000—1,100. Tanneries producing finished leather only, in a limited range and with little colour variation, reach values of 1,500—1,800.

This coefficient decreases as the size of the hides processed in the tannery diminishes. In the case of small hides, the normal average is 700—800; that for very small hides is 450—500.

All the floor space of the tannery buildings must be included in this computation, not only the space devoted to production proper, which generally accounts for not more than 68–70 per cent of the total. If production space only were considered, a very high and misleading rate would be obtained.

The breakdown of floor space in a balanced tannery is as follows:

	Percentage
Production	68
Stores, sorting, shipping	14
Offices, laboratories, bathing facilities, cloakrooms etc.	8
General services	10
	100

Coefficient 3: Yield per hide

$$\frac{m^2}{hide}\left(\text{or the equivalent, } \frac{ft^2}{hide}\right)$$

This coefficient should be applied in order to obtain the maximum possible area of tanned leather from each hide. Most tanners usually do not realize the full potential of each hide, to the great detriment of the tannery's economy.

Using transformation coefficients in the case of a very large hide, of 4 m^2, which gives in addition a flesh-side split of 2 m^2, the economy of the tannery would be optimal if the following area of leather were obtained at the end of the manufacturing process:

Grain (completely finished, coefficient 1)	4.00 m^2
Split (completely finished, coefficient 0.36)	0.72 m^2
	4.72 m^2 (= 51 ft^2)

This is the maximum quantity, in area, that can be obtained from this hide. However, the tanner does not use complete processes all the time. Some of his output is semi-finished, and some taken only to the wet-blue stage. Also, the tanner often sells the splits pickled, so that in the end he is obtaining fewer square metres from his hides than he should.

The conversion coefficients (referred to again in the last part of this work) are as follows:

Stage	*m^2 of grain leather*	*m^2 of split*
Finished	1	0.36
Semi-finished	0.75	0.27
Wet semi-finished	0.58	0.21
Wet-blue	0.33	0.12
Pickled	0.22	0.08
Pelt	0.18	0.07

It can be seen from the example given above that if out of every four hides only one is finished, one semi-finished, one processed as wet-blue and one pickled. and the splits are not tanned but sold pickled, the tanner will obtain the following yield from his hides:

	m^2	m^2
1 Finished	4.00×1	$= 4.00$
1 Semi-finished	4.00×0.75	$= 3.00$
1 Wet-blue	4.00×0.33	$= 1.32$
1 Pickled	4.00×0.22	$= 0.88$
4 Splits	8.00×0.08	$= 0.64$
		9.84

$$\frac{9.84\ \text{m}^2}{4\ \text{hides}} = 2.46\ \text{m}^2 \text{ per hide } (= 26\ \text{ft}^2 \text{ per hide})$$

as against the 4.72 m^2 (= 51 ft^2) obtainable. He obtains only about half the leather yield possible. He earns less money than he should, and his tannery is uneconomical.

Coefficient 4: Power factor

$$\frac{\text{m}^2}{\text{HPi}}$$

This coefficient is the most important in the whole series. It gives an idea of how the power potential of the tannery is transformed into leather. It should be the basic element in all calculations and comparisons since, by establishing equivalences between one tannery and another, it is possible to discover how each establishment is converting its energy potential into square metres of leather.

The average for large hides is 420, though efficient tanneries may hope to achieve rates of 500—550. For small hides, the average is 350—400, and that for very small hides is 250—350.

The calculation of this coefficient must be based exclusively on the horsepower of the direct production machines. The horsepower for general services (boilers, pumps, machine-shop equipment etc.) generally amounts to a further 25 per cent, and if this is added to the calculation a very low and misleading rate will be obtained.

In a balanced tannery carrying out complete production processes the installed horsepower is distributed as follows:

	Percentage
Beamhouse operations	16
Tanning (up to wet-blue stage)	16
Semi-finished, wet	26
Semi-finished	21
Finished	21
	100

By breaking down the installed horsepower of the plant into these five stages it is possible, if desired, to obtain rates for individual sections, which are also often useful.

Coefficient 5: Simultaneity

$$\frac{\text{act. kWh}}{\text{theor. kWh}}$$

This coefficient relates actual electricity consumption to that which would obtain if all the machines were operating simultaneously.

There is no difficulty in obtaining the theoretical consumption figure: the plant's horsepower (total horsepower installed) is multiplied by 0.736 kWh/HP, by 8 hours/day and by 23 days/month, and then by the eleven or twelve months of the year in which the tannery works (there is generally one month in which operations stop for maintenance purposes).

This coefficient does not vary with the size of the hides. In general, when the electricity is supplied entirely from external sources—that is, from the public utility network—it fluctuates between 0.40 and 0.45. When the electricity is supplied entirely by the plant's own generators, the coefficient rises to 0.70—0.75. In practice, these two extreme cases rarely occur. Even when the power comes from an external source it is usual to have a minimum of 20 per cent supplied by the plant, to guard against emergencies. When the electricity is generated internally, 20 per cent can be taken from external sources in order to lessen costs.

Coefficient 6: Consumption of chemicals

$$\frac{\text{kg ch}}{\text{hide}}$$

This coefficient must be regarded as indicative only. The wide range of criteria adopted by tanners, the different methods of operation and the variety of ways in which the different chemicals are used by technicians result in a situation for which it is very difficult to fix a norm. Also, new chemicals are continually appearing on the scene which alter the consumption figures and the operating processes.

For indicative purposes, the following values have been established:

Large hides	10
Small hides	1.5—2
Very small hides	0.85—1

The chemicals are broken down into three subdivisions in order to give a more detailed picture:

(*a*) Beamhouse chemicals (bch) include all the preparatory operations up to that immediately preceding pickling.

(*b*) Tanning chemicals (tch) include not only pickling and tanning but all the supplementary operations needed before the leather is ready for finishing, namely retanning, dyeing, neutralizing, fatliquoring etc. This subdivision requires the largest quantity of chemicals.

(*c*) Finishing chemicals (fch) cover only the finishing operations.

Also for the purpose of guidance, and without attempting to fix a general norm (for the reasons mentioned above), the following rates for the three subdivisions have been established:

	Large hides	*Small hides*	*Very small hides*
$\frac{\text{kg ch}}{\text{kg bch}}$	3.5	3.0	2.7
$\frac{\text{kg ch}}{\text{kg tch}}$	1.5	1.7	2.0
$\frac{\text{kg ch}}{\text{kg fch}}$	30.0	12.6	7.7

Coefficient 7: Fuel consumption

$$\frac{\text{kg fuel}}{\text{m}^2}$$

This coefficient refers exclusively to fuel used for boilers and other heat-producing units. The value fluctuates around 1.6 and shows very little variation between large, medium-sized, small and very small hides. Only in the case of very small hides is there a tendency for it to be higher, namely 1.8—2.

The coefficient has been calculated on the basis of using fuel oil for the boilers. If other fuels with a lower calorific value are used (coal, gas, wood etc.), the necessary adjustments will have to be made. The calorific value of each fuel is estimated at:

	calories/kg
Fuel oil and mixtures	10,500
Natural gas	9,300
Coal	7,500
Wood	3,500

Thus, if the coefficient is converted into $\frac{\text{calories}}{\text{m}^2}$, the result will be:

$$10{,}500 \text{ calories/kg} \times 1.60 \text{ kg/m}^2\text{: } 16{,}800 \ \frac{\text{calories}}{\text{m}^2}$$

The equivalences are as follows:

Fuel oil and mixtures $\frac{16{,}800 \text{ cal/m}^2}{10{,}500 \text{ cal/kg}} = 1.60 \ \frac{\text{kg fuel}}{\text{m}^2}$

Natural gas $\frac{16{,}800 \text{ cal/m}^2}{9{,}300 \text{ cal/kg}} = 1.81 \ \frac{\text{kg fuel}}{\text{m}^2}$

Coal $\frac{16{,}800 \text{ cal/m}^2}{7{,}500 \text{ cal/kg}} = 2.24 \ \frac{\text{kg fuel}}{\text{m}^2}$

Wood $\frac{16{,}800 \text{ cal/m}^2}{3{,}500 \text{ cal/kg}} = 4.80 \ \frac{\text{kg fuel}}{\text{m}^2}$

Coefficient 8: Electricity consumption

$$\frac{\text{act. kWh}}{\text{m}^2}$$

This figure indicates whether or not the kilowatt-hours consumed in a year have been utilized economically. It is a value that fluctuates around 1.8—2, varying very little between large, medium, and small hides. Only in the case of very small hides is it more, varying between 3 and 4.

This eighth is the last in the series of initial coefficients, as explained at the beginning of this chapter. The coefficients that follow, however, are at least as important.

Coefficient 9: Basic

$$\frac{\text{ft}^2}{\text{kg}}$$

(or, if preferred, its equivalent $\frac{\text{m}^2}{\text{kg}}$, but this gives rather inconvenient values from the point of view of calculating).

As will be seen in chapter II this is the basic or initial coefficient used in an analysis of a new tannery or of a proposed alteration or expansion of an existing tannery, as it provides the starting point from which all other calculations must be made.

For large hides, the normal form of production, the average fluctuates between 1 and 2. It is recommended that the value 1.5 be used in calculations.

A good value, indicating profitable use of the raw material, is 1.75. There are, however, highly efficient tanneries (particularly those with a large production scale) that achieve values above 2.

In general, when incomplete production processes are carried out (wet-blue, pickled and semi-finished products) the value is below 1. When nearly all the hides and splits are finished, values around 2 are reached.

In the case of small hides, the coefficient rises to 4 and for very small hides it is higher still, in the neighbourhood of 8.

Coefficient 10: Unit consumption of chemicals

$$\frac{\text{kg ch}}{\text{kg}}$$

This is more informative than **coefficient 6**, $\frac{\text{kg ch}}{\text{hide}}$, as it shows more clearly that the consumption of chemicals increases greatly as the size of the hide decreases, a fact that helps to explain the higher cost of tanning smaller hides.

The coefficient for large hides is 0.41; for small hides it is 0.9; and for very small hides it is 1.7.

The proportions among the three subdivisions (kg bch, kg tch, and kg fch) are the same as those given in **coefficient 6**.

Coefficient 11: Hides per worker

$$\frac{\text{hides}}{\text{worker}}$$

The average for tanneries that produce large hides fluctuates around 1,200 per year. The tanner generally calculates the hides processed by each worker on a daily rather than on a yearly basis, as this is easier for him to deal with. The real output of the workers, however, must be measured in terms of the average for the whole year.

In order that each tannery can make its own calculations, taking into account its particular working conditions (which vary greatly from country to country), some of the more practical rates for hides processed in a day are given:

	Hides per worker-day
Large hides	5—8
Small hides	15—20
Very small hides	25—30

By multiplying these values by the number of working days in the year, the yearly output of hides per worker is obtained. For example, with 220 working days in the year, the coefficients would be:

Large hides	1,100—1,750
Small hides	3,300—4,400
Very small hides	5,500—6,600

These coefficients are calculated on the basis of the whole manual worker force of the tannery, not just on the direct production workers.

Coefficient 12: Output per worker in terms of weight

$$\frac{\text{kg}}{\text{worker}}$$

This coefficient is more reliable than the preceding one, as it gives a better idea of the actual situation. (Although tanners use the previous coefficient much more frequently, it is a bad practice and the values obtained should be regarded as indicative only.) The average in the case of large hides fluctuates around 30,000. This is a key coefficient as it gives the number of kilograms of hides a worker handles during one year.

As in the previous case, all the manual workers of the plant are taken into consideration in calculating this coefficient.

This key number varies according to the characteristics of the country (climatic conditions etc.) and the type of manpower employed in the tannery. If a large number of women are employed, the number of kilograms handled per worker will be less.

When small hides, which require more processing, are being handled, weight of output per worker drops to 6,000 – 15,000. In the case of very small hides, which require more careful work, it is much lower still: 2,000—3,000.

Coefficient 13: Availability of electricity from the plant's generators

$$\frac{\text{HPi}}{\text{kVA}}$$

It is always necessary to provide against the lack or shortage of energy from the public networks and it is very important for a tannery to have its own energy reserves, in the form of one or more generators supplying sufficient kVA to cope with these problems should they arise. Even in the most favourable circumstances, when the supply of electricity from the public network is extremely reliable, 20 per cent of a plant's energy needs should be met by its own generators to offset peak-hour shortages etc. When the external supply is deficient, a plant should aim at supplying 80 per cent of its own energy needs. There is usually a minimum of external energy that can be used to make up the difference. These two limits should be observed when making calculations for the installation of generators.

This coefficient remains the same, irrespective of the size of hides being processed. It varies between 3 and 6, subject to the following comments:

Less than 3 gives a good safety margin

From 3 to 4 is normal

From 4 to 6 is not advisable; it should be used only when there is a guaranteed external supply of electricity

If the coefficient is less than three, there is a good safety margin, since the tannery possesses installed horsepower that is not taken into account in these calculations (machine shop and boiler engines, pumping engines etc.).

The relationship between the total installed horsepower of the establishment and the horsepower considered in these calculations (production machinery only) is generally as follows:

$$\frac{\text{total HPi}}{\text{HPi, production mach. only}} = \text{from } 1.25 \text{ to } 1.40$$

In small tanneries that lack substantial production machinery, the figure is lower—around 1.10.

Coefficient 14: Water consumption

$$\frac{\text{litres}}{\text{hide}}$$

The rule-of-thumb figure used by tanners to calculate water consumption for large hides is:

$$300\ \frac{\text{litres}}{\text{hide}}$$

However, data obtained in a recent analysis of a fairly large group of tanneries, gave higher values:

$$500\text{—}600\ \frac{\text{litres}}{\text{hide}}$$

It has not been possible to establish clearly whether this high figure was due to waste or whether it reflected the actual water requirement. For small hides, the coefficient was much lower, fluctuating between 80 and 150, and for very small hides, it was even less: 30—60.

Coefficient 15: Water consumption per kg of input

$$\frac{\text{litres}}{\text{kg}}$$

This is a key coefficient and is much more useful for calculating purposes than the preceding one.

Average for large hides	25—30
Average for small hides	50—60
Average for very small hides	130—150

Coefficient 16: Transformation

$$\frac{m^2}{\text{kg mach.}}$$

This coefficient may be regarded as the one that indicates the rate at which iron and wood are "converted" into leather.

The machinery installed in a tannery has a certain total weight in kilograms. The tannery produces a certain quantity of leather, in square metres, each year. The relationship between the two values tells how many square metres of leather are produced annually by each kilogram of machinery installed. This machinery is not entirely accounted for by iron: 20—25 per cent of it is made up of wooden vats and drums.

Production machinery exclusively is considered in this calculation. In the case of large hides, the coefficient is generally 2.3. The value decreases with the size of the hides: for small hides it fluctuates between 1.3 and 1.8 while for very small hides it is in the neighbourhood of 1.

Coefficient 17: Weight of individual machines

$$\frac{\text{kg mach.}}{\text{machines}}$$

An analysis of several tanneries processing between 300 and 700 large cattle hides a day, and normally equipped—that is to say, with good machinery, some of it modern, some very modern and some old but in good working condition—gave a value of 2,800 for this coefficient.

It varied very little with the size of the hides, as a rule decreasing slightly with decreasing size. Thus, the value for small hides may be taken as 2,600, and that for very small hides 2,000—2,400.

Coefficient 18: Output of drums

$$\frac{m^2}{\text{litre of drums}}$$

The coefficient for large hides is generally 1. In well-organized tanneries (the average in a country with a well-developed tanning industry) it will be 1.50, and in very modern tanneries with high productivity will reach 1.75—2.40.

This coefficient remains the same, or nearly the same, irrespective of the size of hides.

When vats are used instead of drums in any of the processes, they may be treated as if they were drums, for the purpose of calculation.

Coefficient 19: Litre ratio

$$\frac{\text{litres of water}}{\text{litres of drums}}$$

The rule of thumb widely applied by tanners is to reckon the daily consumption of water as being nearly double the drum capacity (i. e. 1.5—2 litres/day for each litre of drum capacity).

By multiplying this by the number of days actually worked in the year (between 200 and 250), values for this coefficient of between 300 and 500 are obtained.

It should be added that sometimes the tanner makes his calculations on the basis of 1 litre/day per litre of drum capacity, thereby bringing the coefficient down to between 200 and 250.

Coefficient 20: Output of drums

$$\frac{\text{hides}}{\text{litre of drums}}$$

This figure $\left(\text{and its reciprocal } \frac{\text{litres of drums}}{\text{hide}}\right)$ fluctuates around 1, according to the rule of thumb applied by tanners.

It is recommended that the normal value for large hides be taken as between 1 and 2. (The reciprocal will then be between 0.5 and 1.) In the case of small hides the coefficient varies between 2 and 4. For very small hides it is 6—8.

Coefficient 21: Output of drums in kilograms

$$\frac{\text{kg}}{\text{litres of drums}}$$

This is a more useful coefficient than the preceding one because, though the tanner never processes the same size of hides all the time, he keeps a strict check of the quantity in kilograms. The values are as follows: large hides, 13—20; small hides, 5—10; very small hides, 2—5.

Coefficient 22: Boiler output

$$\frac{\text{hides}}{\text{m}^2\ \text{boil.}}$$

This coefficient usually varies between 500 and 700 for large hides. A good figure, however, would be between 700 and 900. Higher figures, from 1,000 to 1,200 or 1,400, are obtained when the hide is only simply processed (e. g. to the wet-blue stage).

The coefficient for small hides rises considerably, and ranges from 3,000 to 4,000. For very small hides, it is ten times as great as that given for large hides: 6,000—8,000.

Coefficient 23: Boiler output in kilograms

$$\frac{\text{kg}}{\text{m}^2\ \text{boil.}}$$

A good coefficient for large hides is between 16,500 and 21,500. Values between 21,500 and 30,000 indicate either low steam production or incomplete production processes (wet-blue, pickled products etc.). Values below 16,500 indicate either antiquated production processes (considerable wastage of steam) or wastage of calories as a result of unsatisfactory installations, poor utilization etc. A reliable value would be 20,000.

The coefficient is lower for small hides, ranging from 7,000 to 10,000. For very small hides it decreases to about one tenth the value for large hides; a reliable figure would be around 2,000.

Coefficient 24: Relationship of floor space to heating area of boilers

$$\frac{m^2\ FS}{m^2\ boil.}$$

This coefficient decreases as the size of the hides processed increases. For large hides, it is around 30; for small hides, 40; and for very small hides, 50.

References to boilers in this and the two preceding coefficients are to standard types of internally fired (vertical or horizontal) boilers, with a steam production of between 15 and 20 kg of steam per hour for each square metre of heating area.

Coefficients 22, 23 and **24** serve very well with boilers of around 80—100 m², fed with fuel oil or mixtures. If other fuels and other types of boilers (old or modern) are used, the values given for these three coefficients should be taken as indicative only.

Coefficient 25: Output in terms of floor space

$$\frac{hides}{m^2\ FS}$$

A very good value for large hides is 25. In the case of incomplete processes (wet-blue) it is 35—45. For small hides the figure rises to 100, and for very small hides it is still higher—150.

Coefficient 26: Relationship of kilograms processed to floor space

$$\frac{kg}{m^2\ FS}$$

The figure recommended as a normal value for large hides is 500. This figure decreases considerably with the size of the hides. For small hides it is 170—200, and for very small hides it is 60—80.

Coefficient 27: Relationship of floor space to horsepower

$$\frac{m^2\ FS}{HPi}$$

This is a key coefficient and is of great importance in planning the buildings and the horsepower to be installed. In the case of large hides, it is around 5. A value between 5 and 6 is recommended. This coefficient remains comparable for all sizes of hide, whether large, medium-sized, small or very small.

Coefficient 28: Processing capacity of the horsepower installed

$$\frac{\text{hides}}{\text{HPi}}$$

The values for large hides fluctuate between 120 and 130; they are more useful in the case of hides of the largest possible size (around 4 m^2).

As the size of the hides diminishes, the value increases considerably. The values for small hides are 500—700; and those for very small hides, 800—900.

Coefficient 29: Processing capacity, in kilograms, of horsepower installed

$$\frac{\text{kg}}{\text{HPi}}$$

The following are the normal averages:

Large hides	2,500—3,000
Small hides	1,000—1,300
Very small hides	300—600

Coefficient 30: Output of the compressors

$$\frac{m^2}{\text{HP compr.}}$$

This value varies greatly, depending on whether complete or partial manufacture is carried out. When production is mainly semi-finished, pickled, wet-blue etc., the tannery does not need many compressors and the coefficient is therefore high, around 15,000—25,000 in the case of large hides.

When a large quantity of totally finished leather is produced, the tannery must have many compressors and the coefficient is low: 4,300—6,000. In this case, a value of around 5,500 is recommended. This coefficient remains the same for small and very small hides.

Coefficient 31: Relationship of water consumption to floor space

$$\frac{\text{litres}}{m^2\ \text{FS}}$$

The recommended value is: 10,000—12,000.

Coefficient 32: Relationship of drum capacity to floor space

$$\frac{\text{litres of drums}}{m^2\ \text{FS}}$$

The recommended value is: 20—35.

II. THE PERFECT TANNERY

On the bas' of the 32 coefficients described in chapter I, it is possible to work out what a tanning establishment would have to be like in order to be regarded as the "perfect tannery".

This exercise assumes a tannery set up for the exclusive processing of large cattle hides. The needs of a similar tannery, processing smaller hides, are summarized at the end of the chapter.

The exercise also assumes that not all the hides will be finished—smaller batches will be sold in incompletely processed states, such as semi-finished or wet-blue. This is generally the case in developing countries.

The following methodology is adopted:

Starting-point (**basic coefficient 9**)

Number of hides to be processed

Establishing the dimensions of the tannery

Over-all picture of the dimensions of the tannery

Calculation of all the possible combinations of parameters, making it possible for tables 1 and 2 to be completed

A. Large hides

Starting point (basic coefficient 9)

The initial parameter aimed at is:

$$1.5\,\frac{ft^2}{kg}\left(=0.139\,\frac{m^2}{kg}\right)$$

Number of hides to be processed

The tannery should produce 300 hides per day, broken down as follows:

50 wet-blue (WB)
50 semi-finished (S-F)
200 finished (F)
300 (leaving 250 splits (S) a day)

The output, in square metres, will be:

	m^2	m^2/day	m^2/day
50 WB	× 3.60 =	180 × 0.33 =	59
50 S-F	× 3.60 =	180 × 0.75 =	135
200 F	× 3.60 =	720 × 1 =	720

The tannery will produce finished splits. Allowance is made for a 20 per cent loss. Thus:

200 S	× 1.20 =	240 × 0.36 =	86
			1,000

The output is calculated using the reduction coefficients given in the commentary on **coefficient 3**

$$300 \text{ hides} \times 24 \text{ kg/hide} = 7{,}200 \text{ kg of hides/day.}$$

The tannery will work forty-eight weeks in a year (allowing one month stoppage for maintenance) at an efficiency rate of 0.9 (allowing for public holidays with pay, strikes, stoppages etc.), giving 230 effective days a year. Thus:

$$230 \text{ days} \times 300 \text{ hides/day} = 69{,}000 \text{ hides/year.}$$
$$230 \text{ days} \times 7{,}200 \text{ kg/day} = 1{,}660{,}000 \text{ kg/year.}$$

Output will therefore be:

$$1{,}660{,}000 \text{ kg/year} \times 1.5 \text{ ft}^2\text{/kg} = 2{,}490{,}000 \text{ ft}^2\text{/year} \; (230{,}000 \text{ m}^2\text{/year})$$

Establishing the dimensions of the tannery

Using the values arrived at in chapter I, it is now possible to fix the dimensions of the tannery.

Building

The average yield per year in terms of floor space is 900 $\frac{\text{ft}^2}{\text{m}^2 \text{ FS}}$ (**coefficient 2**).

The tannery will not try to achieve a higher efficiency rate than this as very high levels of efficiency, in the order of 1,500—1,800, are achieved only in cases where all the leather is finished, whereas this tannery will be devoting part of its production to semi-finished and wet-blue products, which reduce the effective square feet per hide:

$$\frac{2{,}490{,}000 \text{ ft}^2\text{/year}}{900 \text{ ft}^2\text{/(year)/m}^2 \text{ FS}} = 2{,}750 \text{ m}^2 \text{ FS}$$

The distribution of the floor space in the various sections of the tannery will be as follows:

	m^2 *FS*
Production exclusively (68 per cent)	1,870
Storage, offices, laboratories, bathrooms, general services etc. (32 per cent)	880

The machines and equipment within the 1,870 m² of production area will be distributed in the following proportions:

Section	*Percentage*	*m² FS*
Beamhouse (drum liming, fleshing machine, splitting, bating)	25	470
Tanning (*wet-blue*) (pickling and tanning drums)	9	160
Semi-finished, wet (drums for retanning, fatliquoring etc., shaving machine, machines for sammying and setting out)	19	360
Semi-finished (driers)	21	390
Finishing (presses, pigmentation etc.)	26	490
	100	1,870

Machinery

The HPi that will need to be installed is calculated on the basis of 420 m²/HPi (**coefficient 4**).

With very modern machinery, a figure as high as 600 could be reached. However, this tannery will aim at 450 m²/HPi, a figure that is not very easy to reach but which, as the tannery is new, may be attainable.

$$\frac{230{,}000 \text{ m}^2}{450 \text{ m}^2/\text{HPi}} = 510 \text{ HPi}$$

The distribution of this horsepower, by section, will be as follows:

Section	*Percentage*	*HP*
Beamhouse (drum liming, fleshing machine, splitting, bating)	24	122
Tanning (*wet-blue*) (pickling and tanning drums)	14	67
Semi-finished, wet (drums for retanning, fatliquoring etc., shaving machine, machines for sammying and setting out)	28	146
Semi-finished (driers)	20	103
Finishing (presses, pigmentation etc.)	14	72
	100	510

The tannery will have an additional 25 per cent horsepower, or some 120 HP more, for general services (machine shop, boilers, compressors, pumps etc.), which brings the total HPi in the tannery to 630.

Drums

The ratio is generally 1 m² of tanned leather to 1 litre of drum capacity. Organizing the tannery in a way that will ensure a high level of efficiency will give a productivity figure of:

$$1.50 \frac{\text{m}^2}{\text{litre of drums}}$$

The following initial drum capacity will therefore be needed:

$$\frac{230{,}000 \text{ m}^2}{1.50 \text{ m}^2/\text{litre of drums}} = 155{,}000 \text{ litres of drums}$$

For practical purposes, the most convenient numbers and sizes of drums are:

No.	*Type of drum*	*External measurements*	*Litres*
1	Liming	3.50 × 3.50	29,000
1	Tanning	3.50 × 3.00	26,000
2	Retanning, Fatliquoring etc.	2.70 × 3.00	32,000
2	Dyeing	3.00 × 2.00	26,000
		Total	113,000

Thus, a lower capacity than that provided for the calculations is obtained. The coefficient is therefore:

$$\frac{230{,}000 \text{ m}^2}{113{,}000 \text{ litres}} = 2.03$$

This is a very good figure. Tanneries with a very high output achieve a coefficient of 2.40.

Boiler

Coefficient 22 is used to fix the size of the boiler.

A good coefficient is 700—900 $\frac{\text{hides}}{\text{m}^2 \text{ boil.}}$. Taking 800, the following is obtained:

$$\frac{69{,}000 \text{ hides}}{800 \text{ hides/m}^2 \text{ boil.}} = 88.2 \text{ m}^2 \text{ boil.}$$

Assuming a boiler with a heating area of 90 m², the final coefficient will be:

$$\frac{69{,}000}{90} = 766 \text{ hides/m}^2 \text{ boil.}$$

This figure may be checked, using **coefficient 23**:

$$\frac{\text{kg}}{\text{m}^2 \text{ boil.}} = \frac{1{,}660{,}000}{90} = 18{,}450 \frac{\text{kg of hides}}{\text{m}^2 \text{ boil.}}$$

This is a good value as any figure around 20,000 (for large hides) is right.

Water

The annual water consumption in litres is directly linked to the drum capacity by **coefficient 19**. In practice, the range is from 1—1.5 to

$$\frac{2 \text{ litres of water/day}}{\text{litre of drums}}$$

Taking 230 effective days as a basis, consumption is 230, 345 or 460 $\frac{\text{litres of water}}{\text{litre of drums}}$ or 113,000 litres of drums × 230 to 460 =

28,000,000 to 52,000,000 litres of water/year
123,000 to 226,000 litres of water/day.

Assuming the tannery consumes 175,000 litres/day (= 40,000,000 litres/year), the following value will be obtained:

$$\frac{40{,}000{,}000 \text{ litres of water}}{113{,}000 \text{ litres of drums}} = 354, \text{ which is correct.}$$

The following water tanks and pumps will therefore be required:

1 water tank (or several small tanks) with a capacity of 175,000 litres

1 pump of 50,000 litres/hour capacity

1 auxiliary pump of 20,000 litres/hour capacity

It may be noted, however, that if **coefficient 14** is used, a value of $\frac{40{,}000{,}000 \text{ litres}}{69{,}000 \text{ hides}} = 580$ is obtained. This is high, since in practice the coefficient is estimated at 300 to 350—400. (See comments on **coefficient 14**.)

Generators

External energy is cheaper and more convenient than plant-generated electricity as it does not involve installation expenses, purchase of equipment etc. However, it is often unreliable and sometimes difficult to obtain. A combination of the two sources provides the best solution.

In the most favourable circumstances a plant need only generate 15—20 per cent of the energy required (to provide against cuts, drops in voltage etc.). In the worst case, the plant should produce 80 per cent. In practice, 100 per cent plant-generated power is never necessary.

Using **coefficient 13**, the following values are obtained:

$$\frac{\text{HPi}}{\text{kVA}} = 3\text{—}4, \text{ normally}$$

The lower value, 3, is adopted for the sake of caution. Thus:

$$\frac{510 \text{ HPi}}{3} = 170 \text{ kVA}$$

Therefore, a generator of 170 kVA must be installed.

Installed horsepower of compressors

As two thirds of the leather will be completely finished, pneumatic energy for spraying guns will only be needed for this proportion. The requirement is calculated using **coefficient 30**:

$$\frac{\text{m}^2}{\text{HP compr.}}$$

With few compressors, and a correspondingly small proportion of totally finished leather, the coefficient is high: 15,000—25,000. With many compressors, and a correspondingly large proportion of completely finished leather, the coefficient is low: 4,300—5,700. A value around 6,000 $\frac{m^2}{\text{HP compr.}}$ is taken for the purpose of this exercise. Thus:

$$\frac{230{,}000\ m^2}{6{,}050} = 38\ \text{HP compr.}$$

A group of compressors with a total horsepower of 38 will be installed.

Machinery

This item deserves special consideration, since the stock of machinery to be installed cannot be calculated on the basis of coefficients but only (as in the case of drums) by practical planning. However, on the basis of the values given, it is possible to calculate the dimensions of the tannery in terms of "iron".

In general, the coefficient is: 2.30 $\frac{m^2}{\text{kg mach.}}$ **(coefficient 16)**.

This means that, from every kilogram of production machinery installed, 2.30 m² of tanned leather can be obtained in a year. (Tanneries with a high output give values from 3 to 3.30.) Thus:

$$\frac{230{,}000\ m^2}{2.30\ m^2/\text{kg mach.}} = 100{,}000\ \text{kg mach.}$$

Assuming 2,800 kg per machine, this gives:

$$\frac{100{,}000\ \text{kg mach.}}{2{,}800\ \text{kg/machine}} = 35.7$$

Therefore, the number of production machines (in the strict sense) installed will be 35.

Of the total weight of the 35 machines, about 20 per cent is wood (drums, vats etc.) and the remaining 80 per cent is iron.

Production

The physical dimensions of the tannery have now been obtained. However, in order to complete the 24 defining parameters, the production parameters must be calculated.

Personnel and man-hours

The working average is:

$$17\ \frac{ft^2}{\text{m-h}}\ \textbf{(coefficient 1)}$$

However, a good labour productivity rate is envisaged for the plant. The estimates, therefore, will be based on a value of 20. The number of man-hours will therefore be as follows:

$$\frac{2{,}490{,}000 \text{ ft}^2}{20 \text{ ft}^2/\text{m-h}} = 124{,}500 \text{ m-h}$$

Of this total, 25 per cent is non-manual labour (management, technical, administrative personnel etc.). The 124,500 man-hours are consequently distributed as follows:

Manual workers (75 per cent)	93,500
Non-manual personnel (25 per cent)	31,000

The number of people to be employed in the tannery must now be reckoned.

The normal output of work per man, on the basis of 8 hours per day, 23 days per month, amounts to between 1,500 and 1,700 hours a year, after reduction coefficients have been applied that take into account shortages, illness, strikes, stoppages etc. This coefficient varies greatly by country and region. In each case, the particular characteristics of the work force and working conditions have to be kept in mind.

Adopting the figure for an average country (1,600 hours annually; coefficient from 0.85 to 0.92), the following value is obtained:

$$\frac{124{,}500 \text{ m-h}}{1{,}600 \text{ hours}} = 77 \text{ men}$$

With regard to the number of manual workers, and allowing for overtime, a rate of 1,700 hours annually will be assumed:

$$\frac{93{,}500 \text{ w-h}}{1{,}700 \text{ hours}} = 55 \text{ workers}$$

Thus, of the 77 persons employed, 55 are manual workers and 22 are personnel of other categories. Checking with **coefficient 11**, the following output figures are obtained:

$$\frac{69{,}000 \text{ hides}}{55 \text{ workers}} = 1{,}255 \text{ hides per worker (which is ideal)}$$

Coefficient 12 gives the following:

$$\frac{1{,}660{,}000 \text{ kg}}{55 \text{ workers}} = 32{,}000 \text{ kg per worker (also ideal)}$$

Electricity consumption

The tannery has 510 HP of production machinery. The theoretical consumption of these machines would be:

$$510 \text{ HP} \times 0.736 \frac{\text{kW}}{\text{HP}} \times 8 \text{ hours/day} \times 23 \text{ days/month} \times 11.5 \text{ months}$$

$$= 795{,}000 \text{ kWh or, rounded off, } 800{,}000 \text{ kWh/year.}$$

It has been assumed that half a month per year is lost on holidays, maintenance etc.

The practical consumption figure varies between 40 and 45 per cent when the electricity sources are all external (see the comments on

coefficient 5) and between 70 and 75 per cent when all the power used is generated by the plant itself. As these situations hardly ever exist in practice, an intermediate figure of 60 per cent will be adopted. Thus, the actual consumption:

$$800{,}000 \text{ kWh} \times 0.60 = 480{,}000 \text{ kWh}$$

In practice, however, the consumption will be higher as a tannery uses at least an additional 25 per cent of horsepower for machine shop engines, pumps etc.

A check against the actual consumption figures obtained on the basis of **coefficient 8** shows the following:

$$\frac{480{,}000 \text{ kWh}}{230{,}000 \text{ m}^2} = 2.09 \frac{\text{kWh}}{\text{m}^2}, \text{ which is just right.}$$

Fuel consumption

The type of boiler chosen for the tannery has a fuel oil consumption of about $4{,}000 \dfrac{\text{kg fuel}}{\text{m}^2 \text{ boil.}}$

Consequently, annual consumption will be:

$$4{,}000 \frac{\text{kg fuel}}{\text{m}^2 \text{ boil.}} \times 90 \text{ m}^2 \text{ boil.} = 360{,}000 \text{ kg fuel}$$

A check against **coefficient 7** shows:

$$\frac{360{,}000 \text{ kg fuel}}{230{,}000 \text{ m}^2} = 1.56, \text{ which is just right.}$$

Consumption of chemicals

Applying the simple rule given in **coefficient 6** $\left(10 \dfrac{\text{kg ch}}{\text{hide}}\right)$, annual consumption will be found to be:

$$60{,}000 \text{ hides} \times 10 \frac{\text{kg ch}}{\text{hide}} = 690{,}000 \text{ kg ch}$$

The breakdown of this total into the three stages—beamhouse operations, tanning and finishing—is important. Application of the values given in the commentary on **coefficient 6** yields the following:

Beamhouse operations: $\dfrac{690{,}000 \text{ kg ch}}{3.5} = 200{,}000$ kg beamhouse chemicals

Tanning: $\dfrac{690{,}000 \text{ kg ch}}{1.5} = 460{,}000$ kg tanning chemicals

Finishing: $\dfrac{690{,}000 \text{ kg ch}}{30} = 23{,}000$ kg finishing chemicals

Over-all picture of the dimensions of the tannery

The 24 parameters that define a tannery have already been calculated. By setting them out in descending order of magnitude a numerical picture of its dimensions is obtained.

The scale is given below. It may be seen that there is one group of "large numbers", another group of "small numbers" and one parameter that occupies an intermediate position between the two groups.

	Large numbers
1	40,000,000 litres of water
2	2,490,000 ft² of tanned leather
3	1,660,000 kg of raw hides
4	800,000 theoretical kWh
5	690,000 kg of chemicals
6	480,000 actual kWh
7	460,000 kg of tanning chemicals
8	360,000 kg of fuel
9	230,000 m² of tanned leather
10	200,000 kg of beamhouse chemicals
11	124,500 man-hours
12	113,000 litres of drums
13	100,000 kg of machines
14	93,000 worker-hours
15	69,000 processed hides
	Intermediate number
16	23,000 kg of finishing chemicals
	Small numbers
17	2,750 m² of floor space
18	510 HP installed
19	170 kVA
20	90 m² of boilers
21	77 total personnel
22	55 workers
23	38 HP of compressors
24	35 machines

Calculation of all the coefficients

When the parameters have been established and set out in descending order of magnitude, as shown above, the next step is to find all the quotients possible among these items. These are set forth in table 3.

The coefficients in table 3 vary substantially, according to the size of the hides processed by the tannery. In analysing each of the 32 coefficients regarded as essential for an investigation of this kind, the variations of each have been given to correspond with variations in the size of the tanned hides.

B. Small hides

In order to make the study more explicit, table 4, for small hides, may now be drawn up.

It is not necessary to give full details, as in the former case, as the methods followed are exactly the same, only the values being changed. Therefore, only the results of the calculations are given.

Starting-point

The value taken for the starting-point is: $4 \frac{ft^2}{kg} \left(= 0.37 \frac{m^2}{kg}\right)$

Number of hides to be processed

It is assumed that the tannery processes 200,000 hides a year, all finished:

$$200{,}000 \text{ hides} \times 0.65 \frac{m^2}{\text{hide}} = 130{,}000 \; m^2$$

$$200{,}000 \text{ hides} \times 7 \frac{ft^2}{\text{hide}} = 1{,}400{,}000 \; ft^2$$

$$200{,}000 \text{ hides} \times 1.75 \frac{kg}{\text{hide}} = 350{,}000 \text{ kg}$$

Establishing the dimensions of the tannery

Building $\frac{1{,}400{,}000 \; ft^2}{700 \; ft^2/m^2 \text{ FS}} = 2{,}000 \; m^2 \text{ FS}$

Machines $\frac{130{,}000 \; m^2}{400 \; m^2/\text{HPi}} = 325 \text{ HPi}$

Drums $\frac{130{,}000 \; m^2}{1.70 \; m^2/\text{litre of drums}} = 76{,}000 \text{ litres of drums}$

Boilers $\frac{350{,}000 \text{ kg}}{7{,}000 \text{ kg}/m^2 \text{ boil.}} = 50 \; m^2 \text{ boil.}$

Water 200,000 hides × 100 litres/hide = = 20,000,000 litres

Generators $\frac{325 \text{ HPi}}{3 \text{ kVA}} = 110 \text{ kVA}$

HP of compressors $\frac{130{,}000 \; m^2}{5{,}000 \; m^2/\text{HP compr.}} = 26 \text{ HP compr.}$

Machines $\frac{130{,}000 \; m^2}{1.5 \; m^2/\text{kg mach.}} = 87{,}000 \text{ kg mach.}$

Production:

Personnel and man-hours $\frac{200{,}000 \text{ hides}}{4{,}150 \text{ hides/worker}} = 48 \text{ workers}$

Personnel: 48 manual workers
16 other employees

64

Number of hours worked: 76,000 w-h
24,000 man-hours (other employees)

100,000 m-h

Consumption of electricity

Using 325 HPi, a theoretical consumption of

theor. kWh = 500,000 is obtained.

As in the former case, 60 per cent of this is reckoned as actual consumption:

act. kWh = 300,000

Fuel consumption

$$4{,}000 \, \frac{\text{kg fuel}}{\text{m}^2 \text{ boil.}} \times 50 \text{ m}^2 \text{ boil.} = 200{,}000 \text{ kg fuel}$$

Consumption of chemicals

$$0.9 \, \frac{\text{kg ch}}{\text{kg}} \times 350{,}000 \text{ kg} = 315{,}000 \text{ kg ch}$$

$$\text{kg bch} = \frac{315{,}000 \text{ kg ch}}{3.0} = 105{,}000 \text{ kg bch}$$

$$\text{kg tch} = \frac{315{,}000 \text{ kg ch}}{1.7} = 185{,}000 \text{ kg tch}$$

$$\text{kg fch} = \frac{315{,}000 \text{ kg ch}}{12.6} = 25{,}000 \text{ kg fch}$$

Over-all picture of the dimensions of the tannery

	Large numbers
1	20,000,000 litres of water
2	1,400,000 ft² of tanned leather
3	500,000 theoretical kWh
4	350,000 kg of raw hides
5	315,000 kg of chemicals
6	300,000 actual kWh
7	200,000 processed hides
8	200,000 kg of fuel
9	185,000 kg of tanning chemicals
10	130,000 m² of tanned leather
11	105,000 kg of beamhouse chemicals
12	100,000 man-hours
13	87,000 kg of machines
14	76,000 worker-hours
15	76,000 litres of drums

Intermediate number

16	25,000 kg of finishing chemicals

Small numbers

17	2,000 m^2 floor space
18	325 HP installed
19	110 kVA
20	64 total personnel
21	50 m^2 of boilers
22	48 workers
23	34 machines
24	26 HP of compressors

III. SUPPLEMENTARY INFORMATION

A few final words are necessary on the way of measuring the output of a tannery in square metres (or square feet). Standards vary considerably from country to country in this regard and it is difficult to lay down rules.

The final values given in table 2 (below) were calculated for the tanning industry in Argentina. The table was well received as it laid down uniform standards and today is in general use in that country. It will be used as a basis for calculation in this chapter. Obviously, these calculations must be modified for each country studied.

There are four factors, besides the cost of the raw hide, that determine the cost of a tanned hide:

Buildings
Machinery
Labour
Chemicals

Buildings

A study of a sizable group of Argentine tanneries with a good level of production showed the following distribution of floor space (by stage of manufacturing process):

	Floor space (percentage)
Liming and bating (pelts)	25
Tanning (up to wet-blue stage)	9
Semi-finishing, wet	19
Semi-finishing	21
Finishing	26

Machinery

Of all the approaches studied, it would seem that the concept of horsepower installed is the best criterion of the size of the mechanical plant in a tannery.

The distribution of horsepower, per stage of manufacture, shows the following percentages:

	HPi (percentage)
Liming and bating	24
Tanning (up to wet-blue stage)	14
Semi-finishing, wet	28
Semi-finishing	20
Finishing	14

Personnel employed

The man-hours of the personnel employed in a tannery may, on the average, be distributed among the various stages of manufacture in the following proportions:

	m-h (percentage)
Liming and bating	12
Tanning (up to wet-blue stage)	11
Semi-finishing, wet	25
Semi-finishing	24
Finishing	28

Chemicals

For this factory, the $/kg that are consumed at each stage of the manufacturing process have been taken as unit of measurement (valid for Argentine conditions):

	Chemicals (percentage)
Liming and bating	15
Tanning (up to wet-blue stage)	27
Semi-finishing, wet	30
Semi-finishing	5
Finishing	23

These percentages show, for each stage of the manufacturing process, the proportion in which the use of buildings, machinery, labour and chemicals enter into the cost. The coefficients that have been established in the course of this study can now be applied. It is sufficient to use **coefficients 2, 4, 1** and **10**.

Buildings

Floor space used exclusively for:

	ft²/m² FS
Finished leather	900
Semi-finished leather	1,300 (900 × 1.45)
Semi-finished, wet	1,850 (900 × 2.05)
Wet-blue	2,800 (900 × 3.12)
Pelts	4,100 (900 × 4.55)

Machinery

Horsepower installed used exclusively for:

	m^2/HP
Finished leather	420
Semi-finished leather	500 (420 × 1.21)
Semi-finished, wet	635 (420 × 1.51)
Wet-blue	1,200 (420 × 2.86)
Pelts	2,100 (420 × 5)

Personnel employed

Man-hours of total personnel used exclusively for:

	ft^2/m-h produced
Finished leather	17
Semi-finished leather	23.5 (17 × 1.38)
Semi-finished, wet	35 (17 × 2.06)
Wet-blue	73 (17 × 4.3)
Pelts	138 (17 × 8.1)

Chemicals

Each $ 100 of chemicals used exclusively for:

	kg of raw hides processed
Finished leather	2.5
Semi-finished leather	3.25 (2.5 × 1.3)
Semi-finished, wet	3.5 (2.5 × 1.4)
Wet-blue	5.9 (2.5 × 2.36)
Pelts	16.7 (2.5 × 6.7)

If all the resources of the tannery are combined for the purpose of producing finished leather, exclusively, the output figure obtained at the end of the year is what the size of the undertaking permits. In this case, an output of 93,000 m^2 (1,000,000 ft^2) is assumed. This amount is called 1.

If the resources are all used for the purpose of producing, instead, semi-finished leather, a larger quantity of m^2 (ft^2) will be obtained. If they are used for producing wet-blue, exclusively, still more m^2 (ft^2) will be obtained.

How much more? Table 1 gives the coefficients of proportionality just obtained and, in addition, those for pickled products.

TABLE 1. COEFFICIENTS OF PROPORTIONALITY

	Floor space	*Horsepower installed*	*Man-hours*	*Chemicals*
Finished	1	1	1	1
Semi-finished	1.45	1.21	1.38	1.3
Semi-finished, wet . .	2.05	1.51	2.06	1.4
Wet-blue	3.12	2.86	4.3	2.36
Pickled products . . .	4	4.28	6.8	5.7
Pelts	4.55	5	8.1	6.7

It now remains to establish the relative importance of each of the four factors being analysed, that is to say, to weigh them.

In Argentina, capital invested in tanneries shows the following proportions:

	Percentage
Building (m^2 FS)	25
Machinery (HPi)	36
Labour (m-h)	11
Chemicals (ch)	8
Raw hides (kg)	20
	100

Of these five factors, raw hides appear in all cases, irrespective of whether finished leather, semi-finished or wet-blue is being manufactured. Leaving this factor out of account, for the purpose of this calculation, the four remaining factors take on the following proportions:

	Percentage
Building (m^2 FS)	30
Machinery (HPi)	48
Labour (m-h)	12
Chemicals (ch)	10
	100

The weighing needed is therefore a combination of these percentages with the figures given in table 1. This is a simple mathematical calculation:

For finished leather, the result is 1.

For semi-finished leather it is calculated as follows:

$$\begin{array}{l} 1.45 \times 30 + \\ 1.21 \times 48 + \\ 1.38 \times 12 + \\ 1.3 \times 10 \\ \hline \quad 131.14/100 = 1.31 \end{array}$$

Calculating in the same way, results are obtained for:

Semi-finished, wet	1.73
Wet-blue	3.06
Pelts	5.41

These proportionalities mean that the same resources that are applied for manufacturing 1 (for example, one million ft^2 of finished leather) would, if applied to the manufacture of semi-finished leather, produce 1.31 times more (1,310,000 ft^2). This holds true for semi-finished wet, wet-blue, and so on.

It can be seen from the reciprocals of 1.31, 1.73, 3.06, etc. that:

m^2 (ft^2)	*Stage*		m^2 (ft^2) *of finished leather*
1	Semi-finished	=	0.75
1	Semi-finished, wet	=	0.58
1	Wet-blue	=	0.33
1	Pickled products	=	0.22
1	Pelts	=	0.18

These figures, plus those obtained for splits using the same procedure, are summed up in table 2:

TABLE 2. THE CONVERSION COEFFICIENTS FOR YIELD PER HIDE

Stage	m^2 (ft^2) *of grain leather*	m^2 (ft^2) *of split*
Finished	1	0.36
Semi-finished	0.75	0.27
Semi-finished, wet	0.58	0.21
Wet-blue	0.33	0.12
Pickled	0.22	0.08
Pelt	0.18	0.07

Table 3. The perfect tannery — large hides

Parameters[a]	Annual production m²	Annual production ft²	ft²/h	m²/h	m²/LS	Hides	kg	Act. kWh	Theor. kWh	HPh	kg fuel	Workers	Personnel	kg/h	kg/lch	kg/tch	kg/fch	KVA	Litres	m² boil.	HP compr.	Machines	kg mach.	Litres of drums
m²		0,093	2,49	1,87	83,60	3,33	0,1385	0,478	0,287	450	0,64	4,190	2,990	0,333	1,15	0,492	10	1,350		2,555	6,050	6,560	7,80	2,63
ft²	10,74		26,7	20,10	900	35,8	1,49	5,15	3,09	4,840	6,86	45,000	32,100	3,58	12,35	5,29	107,5	14,550	0,0617	27,500	65,000	[illegible]	24,[illegible]	21,85
ft²/h	0,401	0,0375		0,751	33,6	1,34	0,0556	0,193	0,1155	181	0,257	1,680	1,200	0,134	0,463	0,198	4,02	534		1,030	2,440	2,540	[illegible]	[illegible]
m²/h	0,535	0,0497	1,33		44,7	1,78	0,074	0,356	0,154	241	0,341	2,235	1,595	0,178	0,617	0,263	5,35	724		1,370	3,240	3,310	1,53	[illegible]
m²/LS			0,0297	0,0224		0,0398				5,39		50	35,7		0,0138		0,12	16,2		30,6	72,4	75,5	0,0275	
Hides	0,3	0,0279	0,746	0,562	25,1		0,0416	0,144	0,0862	135,5	0,192	1,255	896	0,1	0,345	0,148	3	406		766	1,820	1,965	[illegible]	[illegible]
kg	7,22	0,671	17,95	13,5	603	24		3,46	2,07	3,260	4,61	30,200	21,500	2,4	8,31	3,55	72,1	9,760	[illegible]	18,450	43,600	47,300	16,[illegible]	14
Act. kWh	2,09	0,194	5,19	3,9	170	6,95	0,289		0,598	916	1,33	8,500	6,060	0,692	2,40	1,03	20,9	2,820	0,012	5,200	12,300	13,350	4,8	4
Theor. kWh	3,48	0,323	8,65	6,5	291	11,6	0,487	1,67		1,570	2,22	14,550	10,400	1,16	4	1,71	34,[illegible]	4,[illegible]	[illegible]	[illegible]	21,100	[illegible]	[illegible]	[illegible]
HPh					0,185							0,22	6,63				0,0222	3		5,67	13,4	14,[illegible]		
kg fuel	1,56	0,1455	3,89	2,93	131	5,21	0,217	0,752	0,45	705		6,540	4,670	0,521	[illegible]	[illegible]	15,65	2,120		4,000	9,460	[illegible]	[illegible]	[illegible]
Workers					0,02					0,108			0,715					0,324		0,51	1,45	[illegible]		
Personnel					0,028					0,151		1,4						0,452		0,855	2,03	[illegible]		
kg/h	3	0,279	7,45	5,61	251	10	0,417	1,435	0,863	1,350	1,92	12,550	8,950		[illegible]	1,48	30	4,060	[illegible]	2,670	[illegible]	[illegible]	[illegible]	[illegible]
kg/lch	0,87	0,081	2,16	1,62	72,6	2,9	0,12	0,416	0,25	392	0,556	3,640	2,600	0,286		0,429	8,7	1,175		222	5,260	5,710	[illegible]	[illegible]
kg/tch	2,03	0,189	5,05	3,8	170	6,77	0,282	0,97	0,585	916	1,3	8,500	6,060	[illegible]	[illegible]		20,3	2,750	[illegible]	5,200	12,300	[illegible]	4,0	4,[illegible]
kg/fch	0,1		0,249	0,187	8,36	0,33	0,0139	0,0478	0,0287	45,1	0,0638	418	298	[illegible]	[illegible]	0,0492		135		255	[illegible]	[illegible]	[illegible]	0,204
KVA					0,0617					0,33		3,09	2,21							1,89	4,47	4,8		
Litres	174	16,2	432	325	14,550	580	24,1	83,4	50	78,400	111	725,000	[illegible]	58	[illegible]	58	1,740	[illegible]		445,000	[illegible]	[illegible]	[illegible]	4
m² boil.					0,0323					0,176		1,64	1,17					0,44			[illegible]	[illegible]		
HP compr.										0,0746		0,69	0,492					0,224		0,422		1,08		
Machines										0,0685		0,676	0,455					0,266		0,38	0,375			
kg mach.	0,435	0,0405	1,08	0,812	36,4	1,45	0,0602	0,208	0,125	196	0,278	1,820	1,300	0,146	[illegible]	0,214	4,35	588		1,340	[illegible]	[illegible]		[illegible]
Litres of drums			1,22	0,917	41,1	1,64	0,068	0,235	0,141	222	0,313	2,050	1,465	0,164	[illegible]	0,242	4,91	555		[illegible]	[illegible]	[illegible]	[illegible]	

a) See Introduction, p. 1

TABLE 4. THE PERFECT TANNERY — SMALL HIDES

Parameters[a]	Annual production m^2	Annual production ft^2	w/h	m/h	m^2/TS	Hides	kg	Act. kWh	Theor. kWh	HPh	kg fuel	Workers	Personnel	kg ch	kg [illegible]	kg tch	kg tch	kVA	Litres	m^2 tool.	HP compr.	Machines	kg mach.	Litres of drums
m^2		0.093	1.71	1.3	65	0.65	0.37	0.434	0.26	400	0.65	2,710	2,030	0.41	1.24	[illegible]	8.2	1,360	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ft^2	10.74		18.4	14	700	7.0	4.0	4.66	2.8	4,300	7.0	29,200	21,900	4.44	[illegible]	7.86	86	12,700	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
w/h	0.585	0.054		0.76	38	0.38	0.217	0.253	0.152	234	0.38	1,580	1,190	0.241	[illegible]	0.41	3.04	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	
m/h	0.76	0.072	1.32		50	0.5	0.286	0.333	0.2	308	0.5	2,080	1,560	0.32	[illegible]	0.54	4.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
m^2/TS	0.015		0.026	0.02		0.01				6.15	0.01	41.6	31.2		[illegible]	[illegible]	0.08	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hides	1.54	0.143	2.63	2	100		0.57	0.666	0.4	615	1	4,160	3,120	0.638	[illegible]	1.08	8	1,820	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
kg	2.7	0.25	4.6	3.5	175	1.75		1.17	0.7	1,075	1.75	7,280	5,460	1.11	[illegible]	1.89	14	3,180	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4
Act. kWh	2.3	0.214	3.95	3	150	1.5	0.86		0.6	923	1.5	6,250	4,690	0.95	2.86	1.62	12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Theor. kWh	2.85	0.358	6.57	5	250	2.5	1.43	1.67		1,540	2.5	10,400	7,820	1.59	[illegible]	[illegible]	20	4,550	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HPh					0.162							6.77	5.08				0.013	[illegible]		[illegible]		[illegible]		
kg fuel	1.54	0.143	2.63	2	100	1	0.57	0.666	0.4	615		4,160	3,120	0.638	[illegible]	1.08	8	1,820	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Workers					0.024					0.148			0.75					0.436		[illegible]	[illegible]	4		
Personnel					0.032					0.197		1.33						0.58		[illegible]	[illegible]	[illegible]		
kg ch	2.42	0.225	4.15	3.15	157	1.57	0.9	1.05	0.63	970	1.57	6,560	4,920		[illegible]	[illegible]	[illegible]	2,860	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
kg [illegible]	0.81	0.075	1.38	1.05	52.5	0.525	0.3	0.35	0.21	323	0.525	2,190	1,640	0.33		[illegible]	[illegible]	955	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
kg tch	1.42	0.132	2.43	1.85	92.5	0.925	0.53	0.616	0.37	570	0.925	3,850	2,890	0.59	[illegible]		7.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4
kg tch	0.192	0.018	0.33	0.25	12.5	0.125	0.072	0.083	0.05	76	0.125	520	390	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
kVA					0.055					0.338		2.29	1.72							[illegible]	[illegible]	4		
Litres	154	14.3	263	200	10,000	100	57.2	66.6	40	61,500	100	417,000	313,000	[illegible]	[illegible]	108	800	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
m^2 tool.					0.025					0.154		1.04	0.78					[illegible]			[illegible]	4		
HP compr.					0.013					0.08		0.54	0.41					[illegible]		[illegible]		[illegible]		
Machines					0.017					[illegible]		0.71	0.53					[illegible]		[illegible]	[illegible]			
kg mach.	0.67	0.062	1.14	0.87	43.5	0.435	0.248	0.29	0.174	[illegible]	0.435	1,810	1,360	0.276	[illegible]	0.47	3.48	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		4
Litres of drums	0.585	0.054	1	0.76	38	0.38	0.217	0.253	0.152	234	0.38	1,580	1,190	0.241	[illegible]	0.41	3.04	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	

a) See Introduction, p. 1

HOW TO OBTAIN UNITED NATIONS PUBLICATIONS

United Nations publications may be obtained from bookstores and distributors throughout the world. Consult your bookstore or write to: United Nations, Sales Section, New York or Geneva.

COMMENT SE PROCURER LES PUBLICATIONS DES NATIONS UNIES

Les publications des Nations Unies sont en vente dans les librairies et les agences dépositaires du monde entier. Informez-vous auprès de votre librairie ou adressez-vous à: Nations Unies, Section des ventes, New York ou Genève.

КАК ПОЛУЧИТЬ ИЗДАНИЯ ОРГАНИЗАЦИИ ОБЪЕДИНЕННЫХ НАЦИЙ

Издания Организации Объединенных Наций можно купить в книжных магазинах и агентствах во всех районах мира. Наводите справки об изданиях в вашем книжном магазине или пишите по адресу: Организация Объединенных Наций, Секция по продаже изданий, Нью-Йорк или Женева.

COMO CONSEGUIR PUBLICACIONES DE LAS NACIONES UNIDAS

Las publicaciones de las Naciones Unidas están en venta en librerías y casas distribuidoras en todas partes del mundo. Consulte a su librero o diríjase a: Naciones Unidas, Sección de Ventas, Nueva York o Ginebra.

Printed in Austria

Price: $ U.S. 1.00 (or equivalent in other currencies)

United Nations publication

72-923—March 1973—3,700

Sales No.: E.73.II.B.2

ID/99

4.9.74