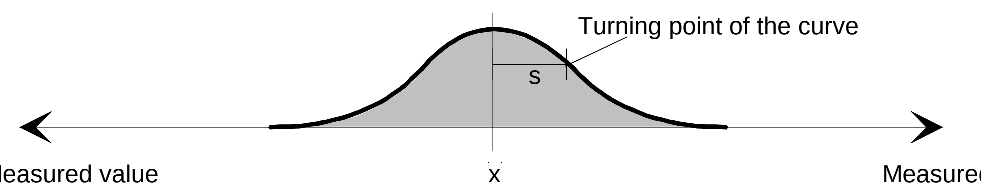
QUALITY DATA STATISTICS (QDS) (9)

1 QDS

An economical production of products can only be guaranteed by current monitoring and constant improvement of the production processes. The quality statistics program enables a quality control integrated into the production by means of different types of quality control cards (process control cards) for the analysis of quality-referred process data. Thus disturbing influences which act on the production process can be recognized early and correcting measures can be set. At the same time the production process gets more transparent and thus better mastered, which leads to a considerable increase in the quality and productivity. But in order to use this program correspondingly, the chosen machine parameters must be in tight connection with the parts quality and shall lie normally distributed.

1.1 TERM NORMAL DISTRIBUTION

In a production process as well as at the manufacture of an injection moulded part it is not possible to exactly reproduce measures (dimensions, part weight). On the process act different disturbing influences, such as e.g. mould wear, material batch variations, filler and colour share changes, temperature variations, irregular closing of the interlock, machine variations etc. From this results a more or less strongly varying parts quality.
The measured values scatter around the set measure and form a frequency there, which decreases symmetrically towards larger and smaller values. When these values are represented in a chart, idealized a bell-shaped curve will result, which is characterized by the mean value (x-cross), equals the most frequent value, and the standard deviation (s), equals the distance of the turning point of the curve from the mean value.



$$s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}}$$

s = standard deviation of a spot check
xi = single measured value of a spot check
$\bar{x}$ = Mean value of the measured values of a spot check
N = Number of measured values of a spot check

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At injection moulding at each machine cycle by the machine control unit a series of process parameters are measured, but which do not all lie normally distributed.
Reasons:
A switching-off or switchover mechanism integrated into the control unit with self-readjustment yields not normal distribution, e.g. opening stroke SFx, metering stroke SSx or that switchover point actual value with which it is switched over to holding pressure.

Products which are produced in several process steps or stem from several similar machnes cannot be normally distributed, even when the products of the individual machines are normally distributed.

A trend of the mean value, i.e. when the mean value is not stationary, for example caused by mould wear or increasing humidity content of the material, can cause a not normal distribution.

All values which are closed loop controlled by a closed control loop show a not normal distribution, e.g. temperatures, clamping force, holding pressure, effective switchover point to holding pressure etc.

Values which should lie normally distributed:
Flow number, mould cavity pressure peak value, all measured switchover point actual values with which it is not switched over, plasticizing time and cushion.

Example of a calculation of the standard deviation for a spot check with 5 measured values of the hydraulic switchover pressure (PHu):

x_i	$\bar{x}$	$x_i - \bar{x}$	$(x_i - \bar{x})^2$
63 65 61 64 62	$\bar{x} = \frac{\sum x_i}{n} = \frac{315}{5} = 63$	0 2 -2 1 -1	0 4 4 1 1
$\sum x_i = 315$			$\sum (x_i - \bar{x})^2 = 10$

$$s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}} = \sqrt{\frac{10}{4}} = \sqrt{2,5} = \underline{\underline{1,58\ \text{bar}}}$$

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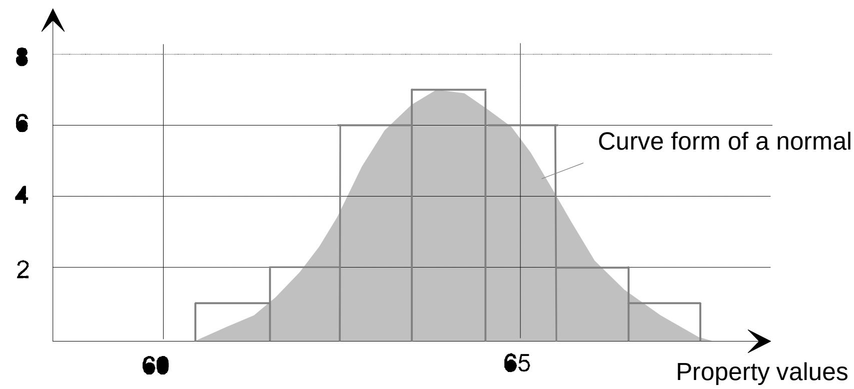
1.1.1 TEST FOR NORMAL DISTRIBUTION (HISTOGRAM)

At the program "Initialization" a number of consecutive spot checks is considered as a single big spot check and the mean value and the standard deviation are calculated, the measured values being represented graphically in a bar diagram (histogram) and checked for "normal distribution".

Example of a histogram with 25 measurements of the hydraulic switchover pressure (Phu) with normal distribution (a smaller than/equal to c)

Number of measured values



$\bar{x}$: 64.0 s: 1.3844 amax: 0.14 c: 0.174

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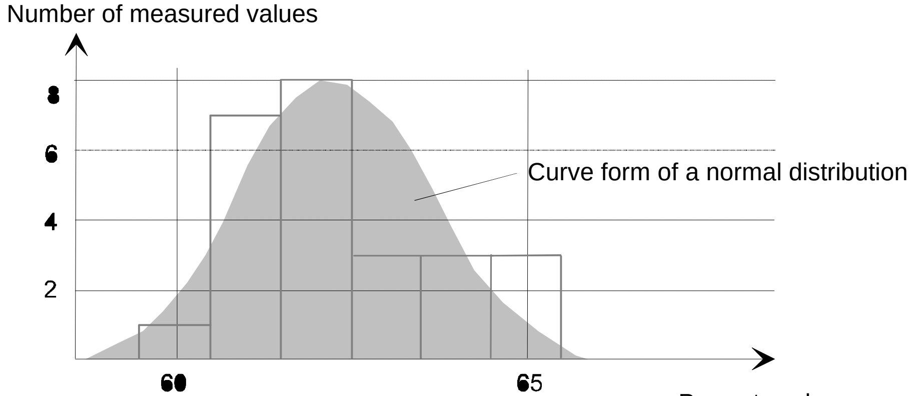
norm.distr.ed

Example of a histogram with 25 measurements of the hydraulic switchover pressure (PHu) with not normal distribution (a larger than c)

Number of measured values



$\bar{x}$: 62.36 s: 1.4369 amax: 0.239 c: 0.174

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not normally distributed

1.2 MACHINE CAPABILITY

For reaching a mastered production it is required to carry out a machine capability examination for each product, only the machine itself being judged as single element of a production sequence. Usually after optimizing the machine a single big spot check (in the normal case a number of consecutive underspot checks, e.g. 5 x 5 pcs) is taken.
To it

- the setting of the machine is not changed during the examination
- the parts are produced without interruption
- only material from one batch is taken.

Process data which are in tight connection with the parts quality (weight, dimensional accuracy, surface) and lie normally distributed are compared to the specification limits. When the result is negative, the process must be reoptimized until the spot checks supply a satisfactory result. Thus the machine capability is reached. The machine capability examination is taken up into the quality statistics program (calibration cycle).

The fixing of the machine capability occurs with the factors Cm and Cmk (C stems from the English ’capability’).

$$C_m = \frac{OSG - USG}{6s} >= 1,33$$

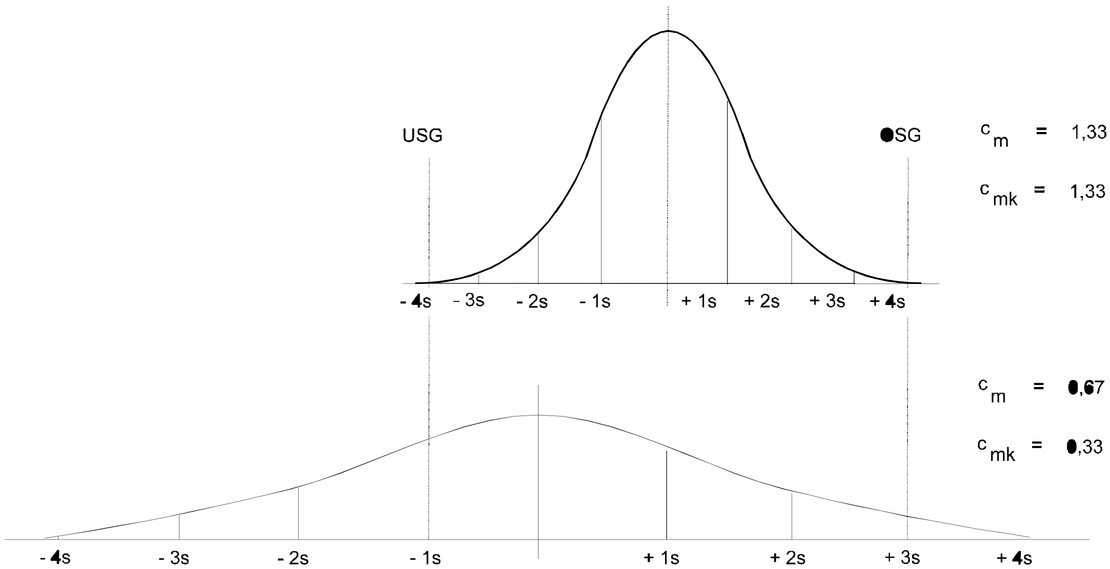
cm compares the upper and lower specification limit (OSG, USG) with the machine scattering 6s, the position of the distribution to the specification limits being ignored. This is determined by calculating cmk.

$$C_{mk} = \frac{OSG - \overline{x}}{3s} \quad \text{or} \quad \frac{\overline{x} - USG}{3s} \quad >= 1,33$$

The smaller of the two values is decisive for juding the current position of the distribution to the specification limits.

At the machine capability it is expected that at least eight standard deviation units lie within the tolerance and/or specification limits whereas at the process capability at least six standard deviation units are expected within the specification limits, but it is always reckoned with six. Therfore at the machine capability examination Cm and Cmk > shall always be = 1.33.

Machine capability characteristic values



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1.3 CONTACT LIMITS

By contact limits disturbing influences which act on the production process can be recognized early and correcting measures can be set in time. The calculation of the contact limits for the mean value and of the standard deviation occurs at the calibration. After passing the calibration cycle, which includes one single big spot check consisting of several subspot checks, on the machine no settings may be changed any longer in order to avoid a falsification of the following statistics.

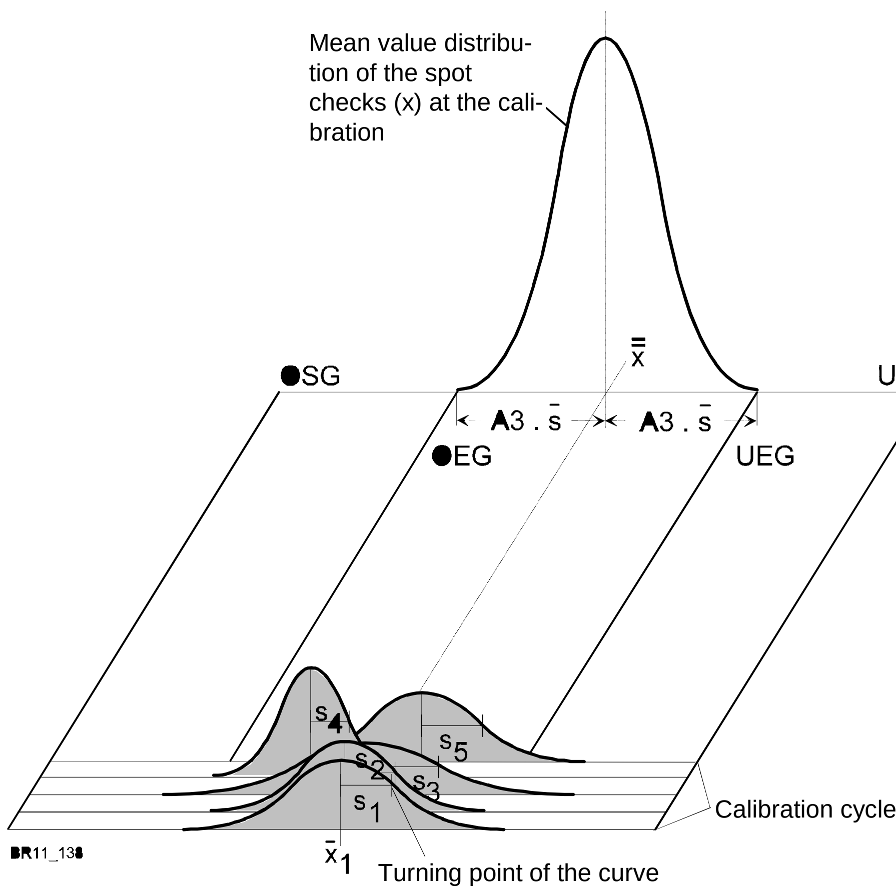
1.3.1 CALCULATION OF THE CONTACT LIMITS AFTER THE MEASUREMENT DISTRIBUTION

Quality control cards, which are developed due to the measured value distribution and the 3 sigma range is used for forming the contact limits,work with the tightest possible limits according to production-technical points of view. The sigma hut range is the estimated value of the standard deviation of the basic entirety (includes all values of the whole production) and is derived from the mean value of the standard deviation (s-cross) of the individual spot checks. Sigma hut is always somewhat larger than s-cross.

For the calculation of sigma hut and of the contact limits constants are required which are in dependence of the number of measurements per spot check. These constants are stored in the control system up to a spot check volume of 25 measured values. Therefore maximally only a number of 25 measurements per spot check can be set.

Excerpt:

n	A3	C4	B3	B4
5	1,427	0,9400	-	2,089
10	0,975	0,9727	0,284	1,716
15	0,789	0,9823	0,428	1,572
20	0,680	0,9869	0,510	1,490
25	0,606	0,9896	0,565	1,435



$$\bar{s} = \frac{s_1 + s_2 + s_3 + s_4 + s_5}{5}$$

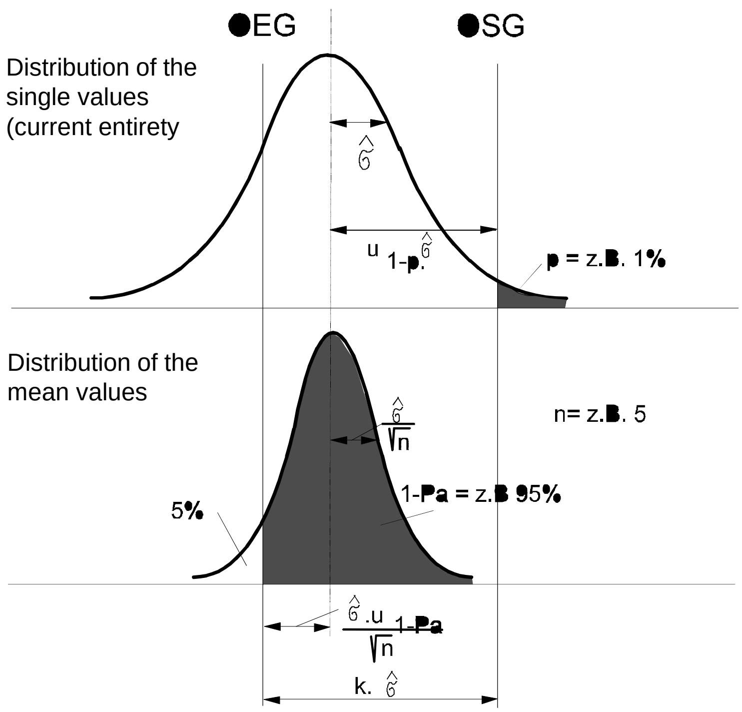
$$\bar{\bar{x}} = \frac{\bar{x}_1 + \bar{x}_2 + \bar{x}_3 + \bar{x}_4 + \bar{x}_5}{5}$$

OEG$\bar{x}$ = $\bar{\bar{x}}$ + A3 . $\bar{s}$	=	(Example) 64 + 1,427 . 1,4 = 66
UEG$\bar{x}$ = $\bar{\bar{x}}$ + A3 . $\bar{s}$	=	(Example) 64 - 1,427 . 1,4 = 62
OEGs = B4 . $\bar{s}$	=	(Example) 2,089 . 1,4 = 2,9
UEGs = B4 . $\bar{s}$	=	(Example) 0 . 1,4 = 0

OEG$\bar{x}$	upper contact limit of the mean value of the spot check
UEG$\bar{x}$	lower contact limit of the mean value of the spot check
$\bar{x}$	Mean value of the spot check (x-cross)
$\bar{\bar{x}}$	Mean value of the spot check mean values (x-cross-cross)
s	Standard deviation
$\bar{s}$	Mean value of the standard deviation (s-cross)
A3	Conversion factors as a function of the volume of the single spot check
B3,B4,OEGs	upper contact limit of the standard deviation
UEGs	lower contact limit of the standard deviation
OSG	upper specific limit
USG	lower specific limit

1.3.2 CALCULATION OF THE CONTACT LIMITS AFTER SET SPECIFIC LIMITS

Where functional points of view point to the fact to allow a larger tolerance range and thus larger limit distances, in the sense of an economical production the tolerance range must be larger than the +/-3 sigma hut range of the current production distribution. As rule of thumb the demand has proven that the tolerance range should at least be equal to or larger than the 12-fold sigma hut range of the production. Only so systematic variations of the process parameters, caused by temperature variations, batch variations and the control behaviour of the injection moulding machine can be allowed in the required measure during the production.
The difference to the previously described control card lies in the calculation of the contact limits for the mean value (x-cross). Depending on the allocation chosen according to economical criteria and thus given of error share (exceeding share p) and contact probability (1-Pa) the distance of the contact limits to the specification limits is calculated. So it can be set with which probability a contact limit alarm is displayed at a certain exceeding share. Before this calculation which occurs at the ”Initialization” the specific limits must be known and set.



$$k \cdot \hat{\sigma} = u_{1-p} \cdot \hat{\sigma} + \frac{\hat{\sigma} \cdot u_{1-Pa}}{\sqrt{n}} \qquad k = u_{1-p} + \frac{u_{1-Pa}}{\sqrt{n}} = 2{,}326 + \frac{1{,}645}{\sqrt{5}} = 3{,}06$$

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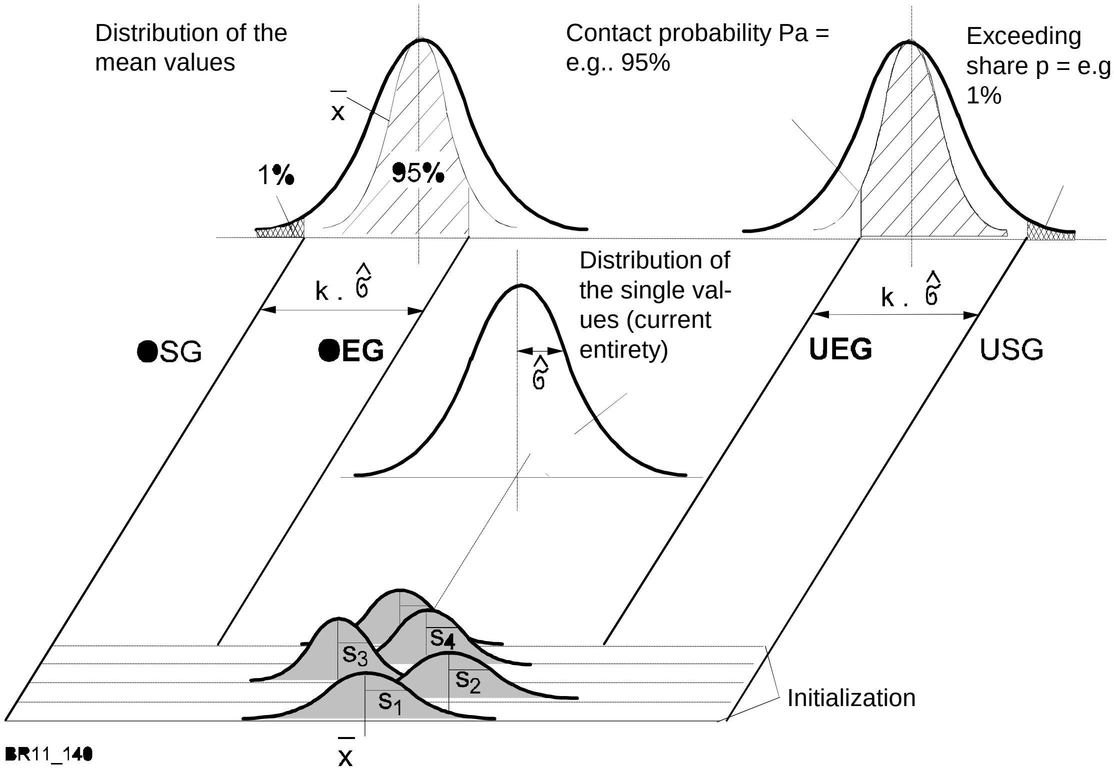
The smaller the allowed exceeding share and the larger the contact probability, the larger gets the distance of the contact limits to the specific limits.
For this example an exceeding share of 1% at a contact probability of 95% and a spot check size of 5 measurements has been assumed.
Starting from the limit values the contact limits are drawn in the distance (k * sigma).



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$$\bar{s} = \frac{s_1 + s_2 + s_3 + s_4 + s_5}{5} \qquad ▮ = \frac{s}{C4}$$

OEG	upper contact limit of the mean value of the spot check
UEG	lower contact limit of the mean value of the spot check
OSG	upper specific limit
USG	lower specific limit
▮	Standard deviation of the entirety at the initialization
k	Calculated value, which changes as a function of the set exceeding share and of the contact probability
$\bar{x}$	Mean value of the spot check
$\bar{s}$	Mean value of the standard deviation

So for this example applies that the control card displays to 95% a contact limit message when an exceeding share of 1% of the entirety is reached.
Factors for calculating the contact limits with an error share p and a
Contact probability 1-Pa.

p (%)	u1-p		1-Pa (%)	u1-Pa
0,1	3,090		99	2,326
0,5	2,576		95	1,645
1,0	2,326		90	1,282
1,5	2,171		85	1,036
2,0	2,054		80	0,842
2,5	1,960		75	0,675
3,0	1,881		70	0,524
3,5	1,812		65	0,385
4,0	1,751		60	0,253
4,5	1,696		55	0,126
5,0	1,645		50	0,000
6,0	1,555		40	0,253
7,0	1,476		30	0,524
8,0	1,405		20	0,842
9,0	1,341		10	1,282
10,0	1,282		5	1,645
15,0	1,036		1	2,326

1.3.3 CONTACT LIMITS CALCULATION AT SPOT CHECK SIZE 1

If the spot check size (i.e. the number of shots / spot checks n) is set to ´1´, only one card is led for the x values. The contact limits are calculated in the following way:

OEGx = xquer + 3 . sigma
UEGx = xquer - 3 . sigma

The s card is omitted in this case. It is not represented on the screen. When printing out, in the s card the value ´0´ is entered.

1.4 PROCESS CAPABILITY

The process capability examination is a long-term examination. For this purpose equally big spot checks at the machine capability examination are taken from the current process over a longer production period. All disturbing influences acting on the process are recorded (directly or indirectly).
In the ideal case all process-relevant actual values would have to flow into the sum frequency formation collected and closed.
This expenditure can be bypassed, however by allocating the actual values to the corresponding classes after each spot check taking and by forming their sum frequency.

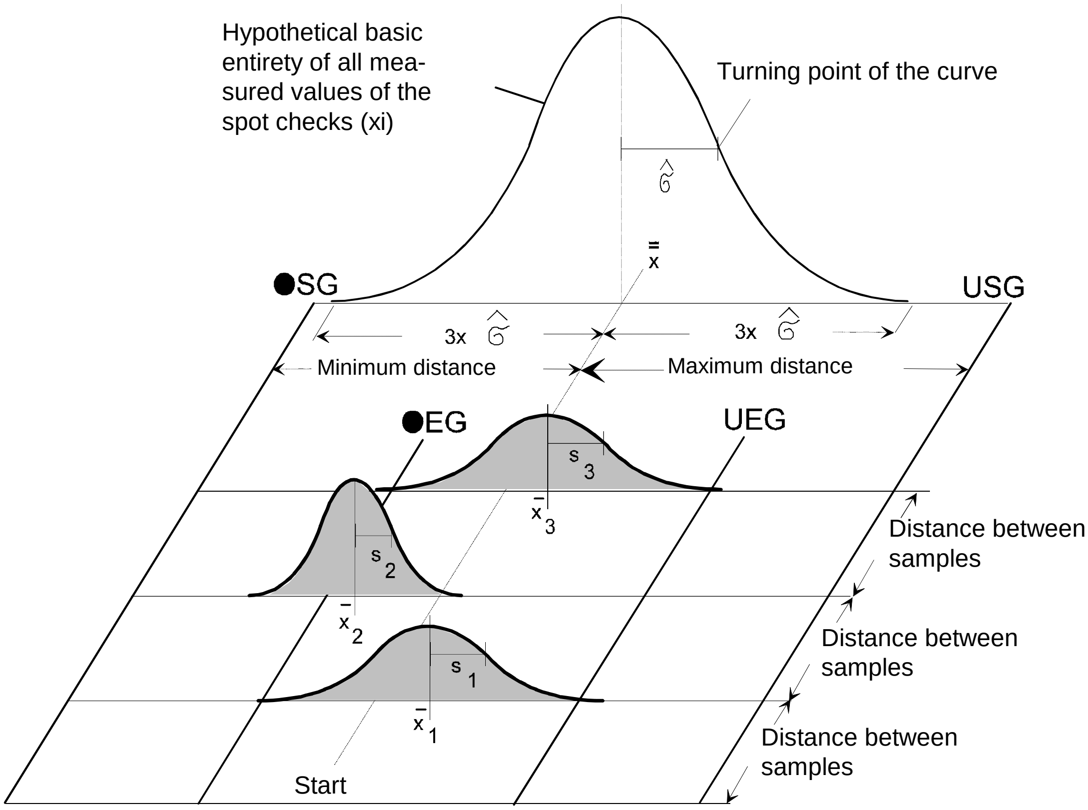
The following calculation of the process capability can only occur when normal distribution exists for the measured actual values. For calculating the process capability usually a tolerance zone given by the parts designer is required for a measure or the weight.

At injection moulding there is now the problem that neither measure nor weight, but a series of process parameters which are in connection with these quality characteristics are recorded automatically. From this results that the process capability can be derived from those process parameters which

- lie normally distributed,
- show a connection to the quality of the product and
- can be occupied with a tolerance zone.

From experience one knows that there is a certain connection between the mentioned normally distributed lying process parameters and the end product, but there are no mathematically defined algorithms for these connections. So for the setting of the tolerances only the way of empirical determination remains. Again under the prerequisite that for a certain process parameter the upper and lower tolerance has been determined correctly, the calculation of the process capability can occur.

The process capability is defined by the values Cp and Cpk.
The characteristic value Cp reflects the relation between specific tolerance zone width and the 6-fold estimated value of the standard deviation (sigma hut).
The characteristic value Cpk indicates the position (mean value) of the process and the process scattering within the specific tolerance limits.
For the process capability only the demand applies that at least all spot check mean values x-cross which lie within the range of plus-minus 3 sigma hut are also within the given tolerance. Thus the characteristic value Cpk shall always be larger than/equal to one.



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$$\hat{\sigma} = \frac{\overline{S}}{C4} = \text{(Example)}\ \frac{1,4}{0,94} = \underline{1,5}$$

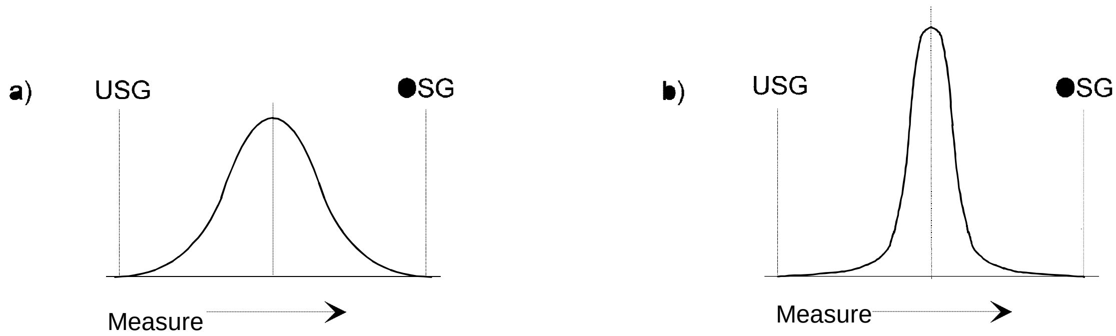
$$C_P = \frac{OSG - USG}{6 \cdot \hat{\sigma}} = \text{(Example)}\ \frac{70 - 58}{6 \cdot 1,5} = \underline{1,33}$$

$$C_{PK} = \frac{\text{Minimum distance}}{3 \cdot \hat{\sigma}} = \text{(Example)}\ \frac{5,5}{3 \cdot 1,5} = \underline{1,22}$$

$\hat{\sigma}$	Estimated value of the standard deviation of the basic entirety (sigma hut)
$\overline{S}$	mean standard deviation
C4	Conversion factor as a function of the spot check volume
Cp	Factor describes the size of the scattering relatively to the specific tolerance
OSG	upper specific tolerance
USG	lower specific tolerance
Cpk	Factor describes the scattering and position to the specific tolerance

PROCESS CAPABILITY

Capable processes (virtually all fabricated products within a specification limit)



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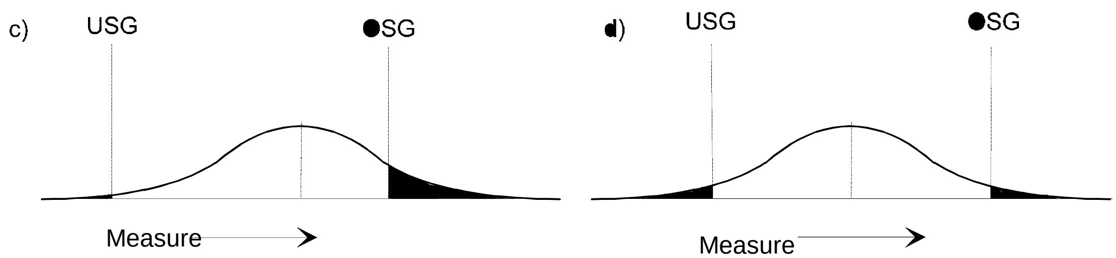
Not capable processes (products outside one or both specification limits are fabricated)



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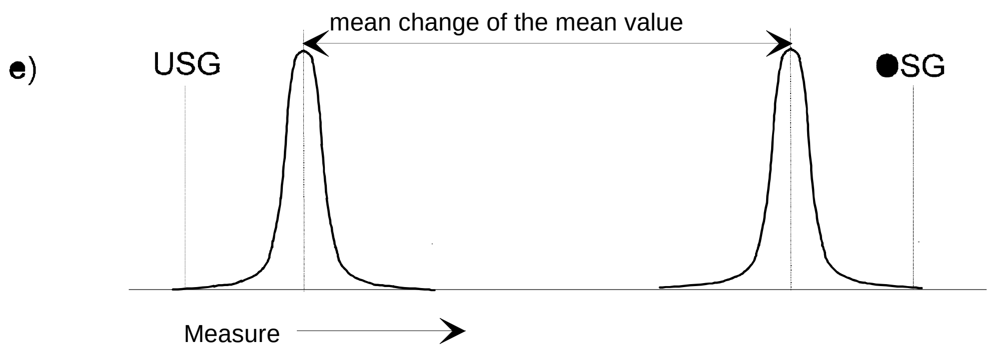
Capable process with systematic deviation



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1.5 QUALITY DATA STATISTICS PROGRAM (QDS)

In order to get a quality data statistics together with documentation, so-called "Quality control cards" must be created and printed out. They serve the current control and improvement of a process and shall help to detect systematic errors in the process happening. Altogether 3 control cards (CC) can be represented in parallel. Besides the automatic recording of the selected parameters at the cycle end it is also possible to enter individual values by hand and thus to create control cards released by the machine cycle with values which are not supplied by the machine, e.g. injection moulded part dimensions.

For those process parameters which lie normally distributed and which are used for the statistic calculation the following evaluations are carried out:

- Setting of the intervals (measured values per spot check, distance between the spot checks) and the spot check number for all process parameters together.
- Calculation and graphic representation of the mean value per spot check (x-cross), of the mean value of the mean values (x-cross-cross) with upper contact limit (OEG) and lower contact limit (UEG). Calculation and graphic recording of the standard deviation (s) per spot check, of the mean value of the standard deviation (s-cross) with upper and lower contact limit.
- After each spot check, calculation and display of the estimated value of the standard deviation of the basic entirety (sigma hut) which supplies a statement about the scattering, calculation of the factor CP, which indicates the relation of the scattering width of the basic entirety to the set specific tolerance, and Cpk, which still includes the position of the scattering to the specific tolerance in additon to Cp. Only the values displayed on the control cards on the screen are used for these calculations.

Automatic CCs	are generated, to each cycle end a transmission of the actual values of the selected parameters occurring to the quality data statistics program.
Manual CCs:	By hand 3 ´quality parameters´ can be input. The recording in CCs occurs in parallel to possibly selected ´automatic´ CCs. For both CC types limit values, spot check sizes etc. separated from each other must be set. The screen pages for the manual CC are designated with´- Q´.

e.g.	CONFIGURATION - Q	--->	Configuration page for the manual CC(s)
	CONFIGURATION	--->	Configuration page for the automatic CC(s)

1.5.1 SELECTION AND SETTING OF THE PARAMETERS FOR THE CONTROL CARDS

Image selection key Q

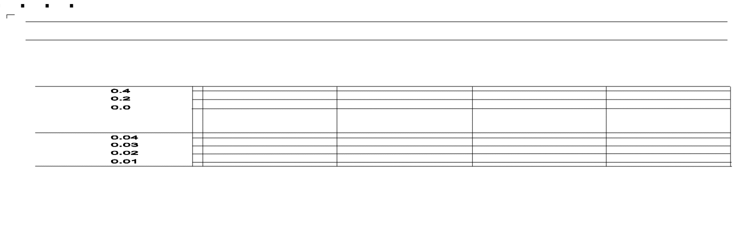
QUALIT

```
Q U A L I T Y   P R O G R A M S        6 - 1              1996-05-20 13:43'

        1  . . .  P R O C E S S  D A T A  R E C O R D
        2  . . .  P D                    G R A P H I C S
        3  . . .  Q U A L I T Y  D A T A  S T A T I S T I C S .
        4  . . .  O P E R A . P O I N T  F I N D I N G .

                    PROG. INTERRUPTION 1
PD        PD         QUALITY-   OPERATING-
RECORD    GRAPHICS   DATA STAT. POINTFIND.
```

At first the machine process must be set to "good parts" and be determined which process data are in direct connection with the parts quality. If no connection can be found, the program cannot be applied. It should also already be fixed within which tolerance limits the measured values must lie in order to be able to produce still "good parts".

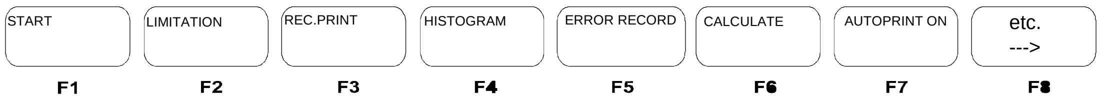
with F3 select "QUALITY DATA STATISTICS"

```
Q U A L I T Y  D A T A  S T A T I S T I C S  6 - 1       1996-05-20 13:43'
          . . . . .          . . . . .          . . . . .

      n: 5          M:   5           Distance: ..          SZx: ....
      SW: ....      OSG: ....        USG:     ....         IW:  0.0 bar
S Z x :   . . . .
T i m e :
```




```
measurements: 0            under spec: 0    0.0 %         over spec: 0    0.0 %
UEGX: 0.00           OEGX: 0.00             UEGX: 0.00           OEGS: 0.00
   x̄: 0.00           ▌: 0.00         s̄: 0.00       Cp: 0.00         Cpk: 0.00

                    PROG. INTERRUPTION 1
CONTROL CARDSPECIFIC. EINGRIFFS- CON-       CONTROL-   QDS-ERROR QUALITY-  etc.
            LIMITS     LIMITS    FIGURATION CHART TYPE DELETE    PROGRAM   --->
```

With the command 2 times "etc" switch over to the 3rd command line.



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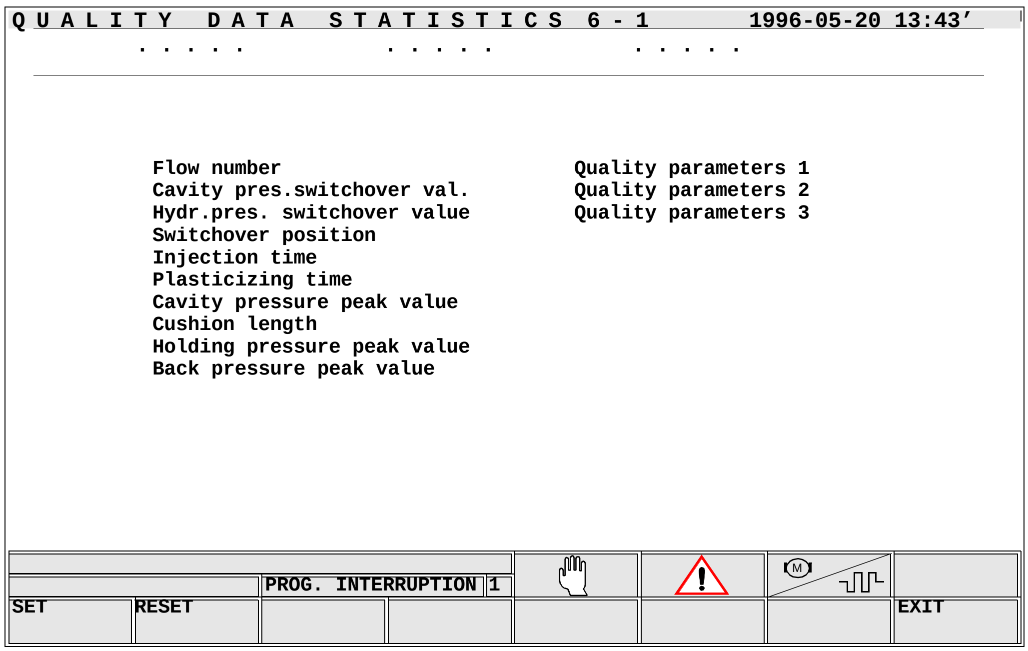
- "Select "SET" (F2), through which on the screen in the left column 10 parameters (actual values), which can be used for statistics, appear. In the right column 3 quality parameters are ready for the selection for a manual control card.



- "Choose "SET", move the green zone with the cursor keys to the corresponding parameter and press "SELECTION". The value appears on the upper screen edge. With the instruction "RESET" one can erase a selection. Repeat this process for several control cards.
- With "EXIT" the screen switches back to the graphic image.

With the "leafing keys"  TAST_V_Z  one selects between the 3 control cards.

1.5.2 MANUAL CONTROL CARD

Screen page for the input of the quality parameters:
From the main menu ´etc´ and then F6 ´QUALITY VALUES´

```
QUALITY VALUES              6 - 1              1996-05-20 13:43'

   QP shot counter                         270 Sch

   Quality parameter 1 measured value 2.10
   Quality parameter 2 measured value 5.70
   Quality parameter 3 measured value 0.00

   Shot / spot check                  n   = 12 Sch
   Number of samples                  m   = 10

   Number of the input measurements       = 18

                     PROG. INTERRUPTION 1
CONTROL CARD                                  TAKEOVER   QUALITY-
                                                         PROGRAMS
```

Set all limits, spot check volume, shot / spot check. Also set the QP shot counter. This serves as mere display value in the control card and has no connection with the production shot counter.
After the process run and/or the initialization run has been started (function key F1 ´START´) the input of the quality parameters can occur, which are selected for the RK. Each input is entered into the RK with F6 ´TAKE OVER´: The counter ´Number of the input measurements´ displays the sum of the recorded inputs.
When the size (m x n) is reached (spot checks times shot per spot check), no further inputs are assumed any longer.

1.5.3 INITIALIZATION

Q D S - S P E C I F I C   L I M I T S   6 - 1   **1996-05-20 13:43'**

					Setting limitations:
Stop after 'specific limits exceeded'		NO			Yes / No
Rejects after 'specific limits exceeded'		NO			Yes / No
SPECIFIC LIMITS:	SET VALUE.	LOWER (USG)	UPPER (OSG)		
Flow number	.....	.....	.....		0 - 999.9
Cav.pr.switchover.	.....	.....	.....	bar	0 - 6553.5
Hyd.pr.switchover.	.....	.....	.....	bar	0 - 999.9
Switchover position	.....	.....	.....	mm	0 - 999.9
Injection time	.....	.....	.....	s	0 - 6553.5
Plasticizing time	.....	.....	.....	s	0 - 999.9
Cavity pres.	.....	.....	.....	bar	0 - 6553.5
Cushion length	.....	.....	.....	mm	0 - 6553.5
Holding pres. max.	.....	.....	.....	bar	0 - 999.9
Back pres. max.	.....	.....	.....	bar	0 - 999.9

		PROG. INTERRUPTION 1					
CONTROL CARD	SPECIFIC. LIMITS	EINGRIFFS. LIMITS	CON- FIGURATION	CONTROL- CHART TYPE	QDS-ERROR DELETE	QUALITY- PROGRAM	etc. --->

With the initialization occurs the check for normal distribution, examination for machine capability and calculation of the contact limits at the same time. For the machine capability examination and when the contact limits shall occur after the specific limits, the specific limits must already be set before. For the automatic RK the machine must run in the automatic mode and produce good parts.

- Select screeen page "SPECIFIC LIMITS". For the previously selected parameters set the values corresponding to the quality criteria.
- For manual input choose the analog screen page "SPECIFIC LIMITS - Q"

- Select screen page "CONFIGURATION" and set shot per spot check, number of the spot checks, distance between the spot checks and for the histogram the number of the classes.
  If too many spot checks are set, the error message ´TOO MANY SPOT CHECKS´ appears in the interactive error message field.
- For manual input choose the analog screen page "QDS - CONFIGURATION - Q".
  The values input here only apply to the quality parameters and are independent of the sizes for the process parameters.

Q D S - C O N F I G U R A T I O N 6 - 1 1996-05-21 11:43’

			Setting limitations:
Shot / spot check	n = 5	Sch	1 - 25
Number of samples	m = 10	Sch	1 - 99
Distance between spot check	0	Sch	1 - 999
Number of classes for histogram	10		1 - 20 1)
Print also time	YES		Yes / No
Print also shot counter	YES		Yes / No

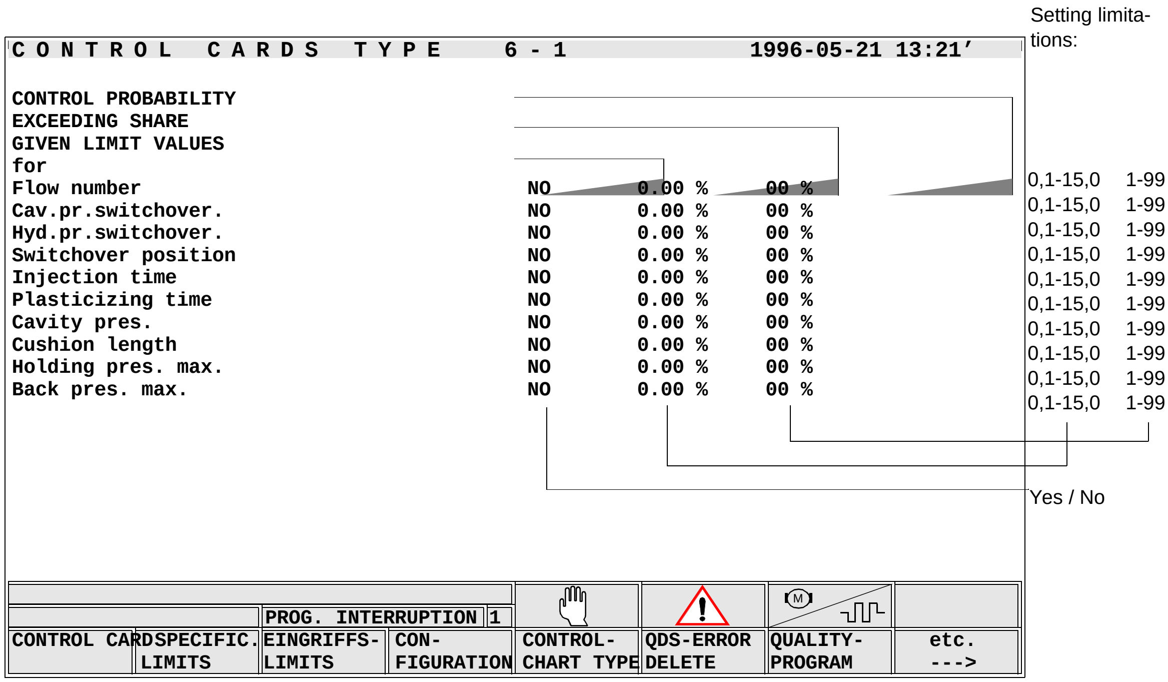
SCALES	Auto / manual Setting	XQUER (max.)	S (max.)	xcross	s
Flow number	AUTO	0.00	0.000	655,35	65,535
Cav.pr.switchover.	AUTO	0.0	0.00	6553,5	655,35
Hyd.pr.switchover.	AUTO	0.0	0.00	6553,5	655,35
Switchover position	AUTO	0.00	0.000	655,35	65,535
Injection time	AUTO	0.00	0.000	655,35	65,535
Plasticizing time	AUTO	0.00	0.000	655,35	65,535
Cavity pres.	AUTO	0.0	0.00	6553,5	655,35
Cushion length	AUTO	0.00	0.000	655,35	65,535
Holding pres. max.	AUTO	0.0	0.00	6553,5	655,35
Back pres. max.	AUTO	0.0	0.00	6553,5	655,35

		PROG. INTERRUPTION 1					
CONTROL CARD	SPECIFIC. LIMITS	EINGRIFFS-LIMITS	CON-FIGURATION	CONTROL-CHART TYPE	QDS-ERROR DELETE	QUALITY-PROGRAM	etc. --->

1) in the case ´0´ occurs an automatic determination of the class size. The used minimum class size is 4.

At the initialization the distance between the spot checks must be set to ”0”. If it is set to automatic scale, the graphic recording of the control cards depends on the specific limits. The scale can be set for each control card individually when it is switched to ”MANUAL” by typing in the figure ”1”.

- If the contact limits shall be calculated according to previously fixed specific limits, select screen page ”CONTROL CARDS TYPE”, set ”YES” and input the exceeding share and the contact probability in per cent.
- For manual input choose the analog screen page ”CONTROL CARDS TYPE - Q”.

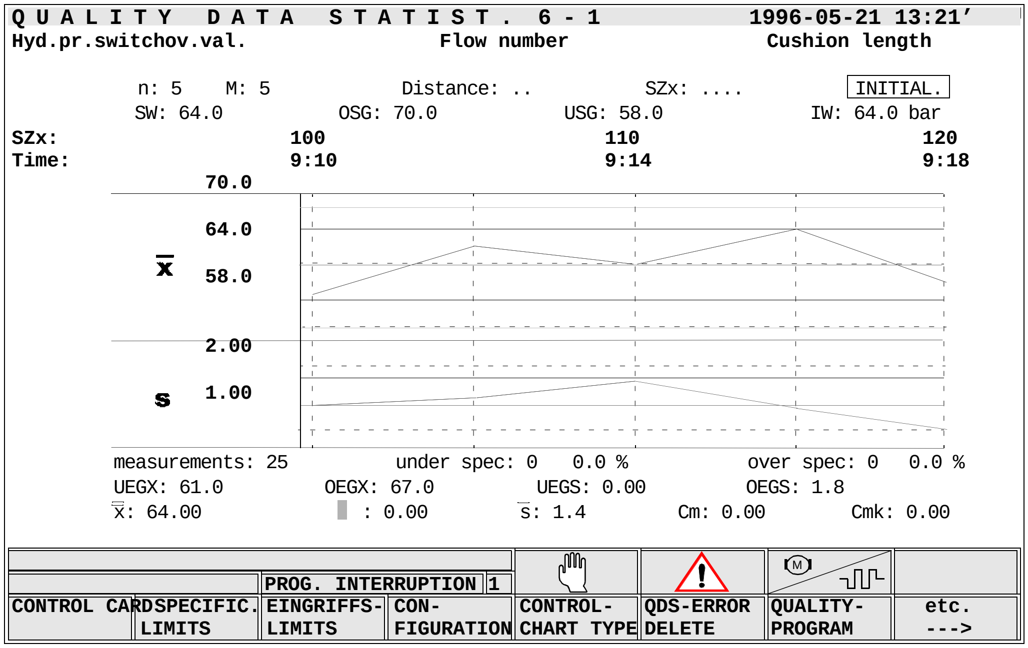


- After reselection of the control card and of the second command line start the initialization with the command "START". After choosing "START" a subcommand line appears on the screen:

"PROCESS RUN" "INITIALIZATION"

PROCESS RUN:	Starting of the process data statistics (process capability)
INITIALIZATION:	Starting of the calibration cycle

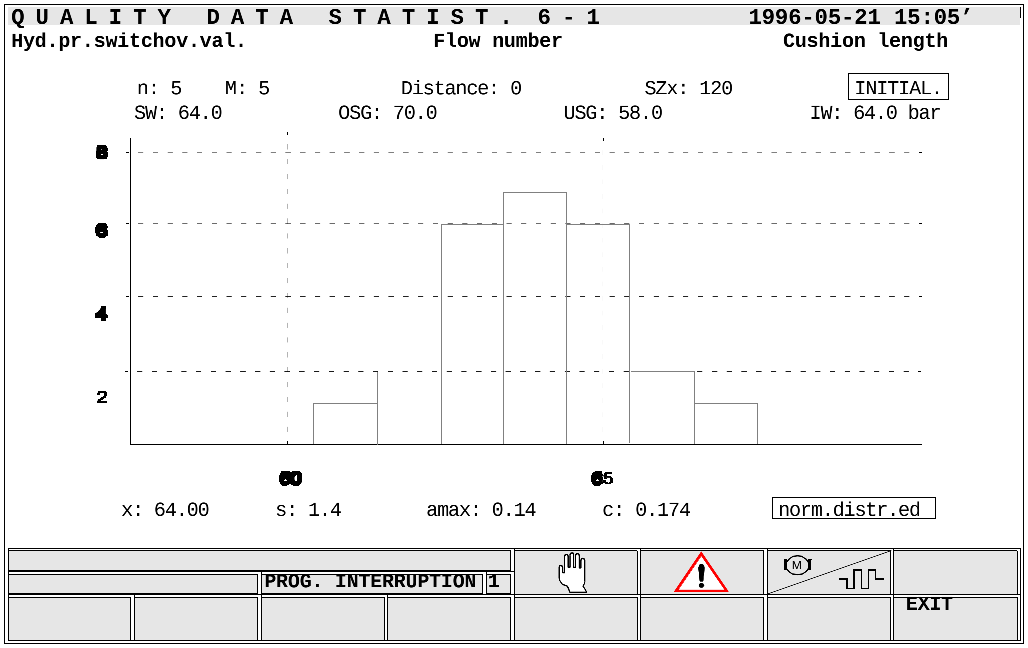
- Here one selects ´Initialization´. At the right above the control card appears "INITIAL".



After the initialization occurs the soft key change from ´STOP´ to ´START´ only then when the initialization for all cards is completed. So at a mixture of process and quality parameters for both types.

After the expiry of the calibration cycle the values x-cross and s are calculated for the big spot check (consisting of several subspot checks) made at the initialization and displayed in the histogram. At the same time also the values x-cross-cross and s-cross (calculated from the subspot checks) are taken over automatically as set value for the process data statistics, the contact limits are calculated and stored.

- Select the histogram and check whether the process parameter used for the statistics lies normally distributed.



When the measured values do not lie normally distributed, the calculations of the standard deviation, contact limits and machine capability loose somewhat of expressiveness, but the use of the calculations seems to be a reasonable decision also for not normally distributed characteristics.

1.5.4 STARTING OF THE QUALITY DATA STATISTICS

So after the expiry of the calibration cycle and automatic stop of the QDS the contact limits and set value are assured, which are starting points for the actual "PROCESS RUN". The settings for number of the spot checks and the distance between the spot checks are chosen. The value shot/spot check must be the same as in the initialization mode as it was the basis for the calculation of the contact limits (A3 constant) and is used for their monitoring.

- Select the screen image "CONFIGURATION", set the number of the spot checks and the distance between the spot checks. Possibly change the scale of the graphic recording when the curve is represented very small.

Q D S - C O N F I G U R A T I O N 6 - 1 1996-05-21 11:43'

					Setting limitations:
Shot / spot check		n = 5 Sch			2- 25
Number of samples		m = 10 Sch			1 - 99
Distance between spot check		0 Sch			1 - 999
Number of classes for histogram		10			10 - 20
Print also time	YES				Yes / No
Print also shot counter	YES				Yes / No
SCALES	Auto / manual Setting	XQUER (max.)	S (max.)		xcross s
Flow number	AUTO	0.00	0.000		655,35 65,535
Cav.pr.switchover.	AUTO	0.0	0.00		6553,5 655,35
Hyd.pr.switchover.	AUTO	0.0	0.00		6553,5 655,35
Switchover position	AUTO	0.00	0.000		655,35 65,535
Injection time	AUTO	0.00	0.000		655,35 65,535
Plasticizing time	AUTO	0.00	0.000		655,35 65,535
Cavity pres.	AUTO	0.0	0.00		6553,5 655,35
Cushion length	AUTO	0.00	0.000		655,35 65,535
Holding pres. max.	AUTO	0.0	0.00		6553,5 655,35
Back pres. max.	AUTO	0.0	0.00		6553,5 655,35

		PROG. INTERRUPTION 1					
CONTROL CARD	SPECIFIC. LIMITS	EINGRIFFS- LIMITS	CON- FIGURATION	CONTROL- CHART TYPE	QDS-ERROR DELETE	QUALITY- PROGRAM	etc. --->

- Afterwards one starts the QDS with "START" and "PROCESS RUN".
- This begins with the measuring distance!

Q U A L I T Y D A T A S T A T I S T . 6 - 1 1996-05-21 13:21'

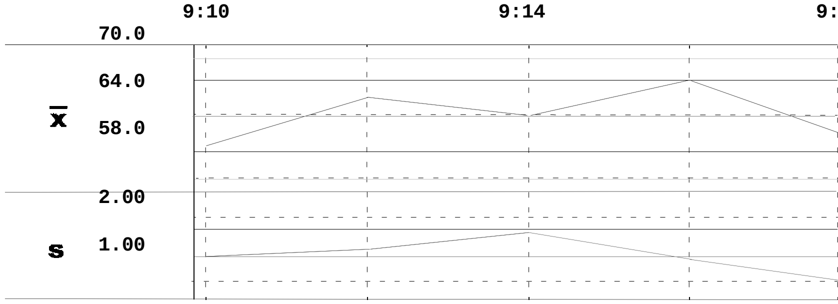
Hyd.pr.switchov.val. Flow number Cushion length 1)

n: 5 M: 5 Distance: .. SZx: .... INITIAL.

SW: 64.0 OSG: 70.0 USG: 58.0 IW: 64.0 bar 2)

SZx: 100 110 120 3)

Time: 9:10 9:14 9:18



4)

5)

measurements: 25 under spec: 0 0.0 % over spec: 0 0.0 %

UEGX: 61.0 OEGX: 67.0 UEGS: 0.00 OEGS: 1.8 6)

x̄: 64.00 ▮ : 0.00 s̄: 1.4 Cm: 0.00 Cmk: 0.00

		PROG. INTERRUPTION 1					
CONTROL CARD	SPECIFIC. LIMITS	EINGRIFFS- LIMITS	CON- FIGURATION	CONTROL- CHART TYPE	QDS-ERROR DELETE	QUALITY- PROGRAM	etc. --->

After each spot check the values x-cross-cross, s-cross, sigma hut, Cp and Cpk are calculated as well as s and x-cross are recorded graphically.

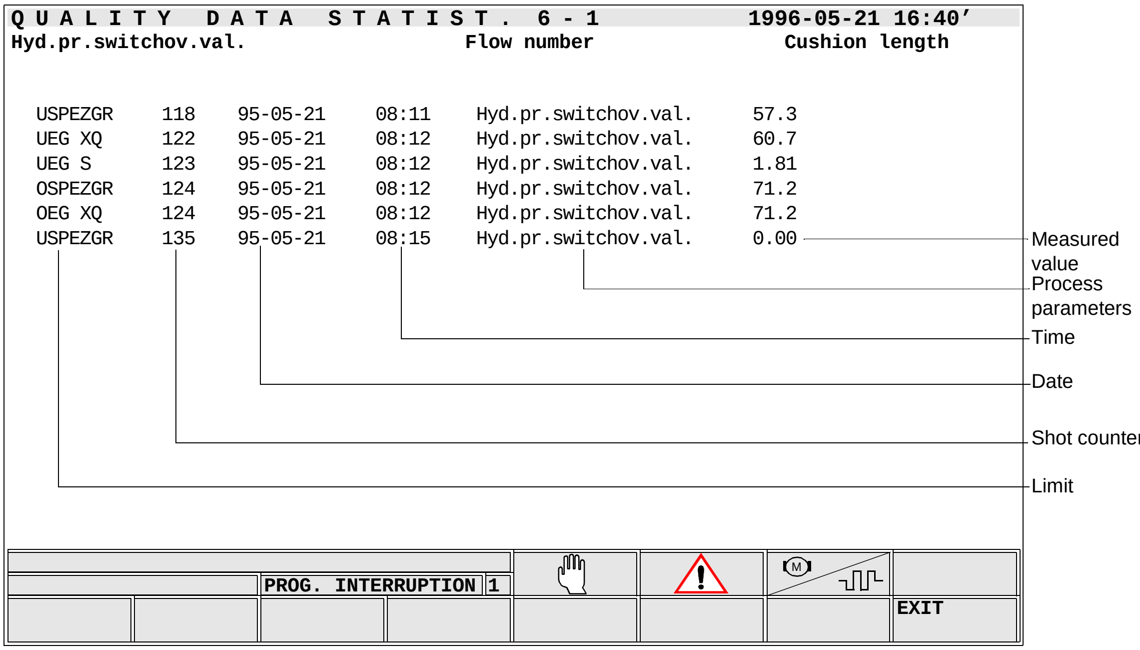
Description of the control card:

1) Indication of the chosen parameters for the 3 control cards

2)	n:	Indication of the shots per spot check	
	m:	Indication of the number of spot checks	
	Distance:	Indication of the distance between the spot checks	
	SZx:	Production shot counter is only updated when statistics is started newly. At manual RK: Value which can be input. Screen page ´QUALITY VALUES´	
	SW:	In the calibration cycle: chosen set value, in the normal cycle: x-cross-cross value transmitted from calibration cycle	
	OSG:	Upper specific limit of x	
	USG:	Lower specific limit of x	
	IW:	Current actual value of x	
3)	SZx:	The shot counter and the	
	Time :	Time measured as additional information at the end of the respective spot check	
4)	x-quer:	Graph of the mean value	
		Red lines:	Contact limits
		Yellow lines:	specific limits
		Blue line:	x-quer-quer
		Green line:	x-quer
5)	s:	Graph of the standard deviation	
		Red lines:	Contact limits
		Yellow lines:	specific limits
		Blue line:	s-cross
		Green line:	s
6)	measurements: ..	Number of measurements and/or cycles from start of the statistic recording without the distances between the spot checks	
	under spec: ...	Number of checks which lay under the specific limit. Absolutely and in per cent.	
	over spec: ...	Number of checks which lay over the specific limit. Absolutely and in per cent.	
	OEGX:	Upper contact limit of x-cross	
	UEGX:	Lower contact limit of x-cross	
	OEGS:	Upper contact limit of s	
	UEGS:	Lower contact limit of s	
	x-quer-quer: ..	Current mean value of the mean values. Digital display of the blue straight line in the x-cross graph	
	Sigma hut: .	Estimated value for the standard deviation	
	s-cross:	Mean value of the standard deviation	
	Cp:	Process capability index, only includes the scattering	
	Cpk:	Process capability index, includes beside scattering also the position of the mean value to the specification limits.	

1.5.5 ERROR MESSAGES AND MANUAL SETTING OF THE CONTACT LIMITS

During the process run when exceeding the contact limits the error message ”QDS-CONTACT LIMIT XQ” arises, when exceeding the specific limits ”QDS-SPEC.LIMITS”. The alarm lamp flashes and the error is stored. With the command ”ERROR RECORD” it can be read off on the screen which of the process parameters has released the error and/or in which direction the limit has been exceeded.



The error message and the alarm lamp can be erased with the instruction ”ERASE QDS ERROR” during the automatic mode.

If an error appears, the machine stops the cycle as a function of the screen switches ”CONTACT LIMITS” and ”SPECIFIC LIMITS”:

```
Q D S  -  S P E C I F I C  L I M I T S  6 - 1          1996-05-20 17:06’

Stop after ’specific limits exceeded’                        NO



SPECIFIC LIMITS:                UEGx        OEGx        UEGs        UEGs

Flow number                     .....       .....       .....       .....
Cav.pr.switchover.              .....       .....       .....       .....
Hyd.pr.switchover.              .....       .....       .....       .....
Switchover position             .....       .....       .....       .....
Injection time                  .....       .....       .....       .....
Plasticizing time               .....       .....       .....       .....
Cavity pres.                    .....       .....       .....       .....
Cushion length                  .....       .....       .....       .....
Holding pres. max.              .....       .....       .....       .....
Back pres. max.                 .....       .....       .....       .....
```

		PROG. INTERRUPTION 1					
CONTROL CARD	SPECIFIC. LIMITS	EINGRIFFS. LIMITS	CON- FIGURATION	CONTROL- CHART TYPE	QDS-ERROR DELETE	QUALITY- PROGRAM	etc. --->

The calculation of the contact limits occurs in the calibration cycle. A manual change is also possible on the screen image ”CONTACT LIMITS”.

1.5.6 PRINTOUT, CALCULATION AND STORAGE OF THE STATISTIC RECORDING

If a graphic printer is connected to the control unit, with the command ”PRINT” the printing of the selected control card starts. The printer should be set to narrower type matter (say 15 cpi). The command ”AUTOPRINT ON” causes an automatic printing of the corresponding control card after each complete recording. If also the shot counter and the time shall be printed, the switches on the screen image ”CONFIGURATION” must be set to ”YES”.

With the command ”CALCULATE” for a control card the specific limits can be calculated newly with 3- or 4-fold sigma hut or the contact limits can be calculated newly corresponding to the last spot check.
The values calculated at the initialization and the graphic recording are erased.
With command ”STOP” the statistic recording can be interrupted. After renewed start the graphics is erased and the recording begins anew.