

Corso di

APPLICAZIONI INDUSTRIALI

(Indirizzo MECCANICO)

Ing. Riccardo Bongiovanni

Parte 6 - Gli strumenti per il controllo

STUMENTI DI MISURA A *'MISURA DIRETTA'*

METRO, CALIBRO E MICROMETRO

STUMENTI DI MISURA A *'MISURA PER CONFRONTO'*

COMPARATORE, ALESAMETRO E TASTATORE

CALIBRI FISSI

BLOCCHETTI DI RISCONTRO, TAMPONI P-NP E ANELLI DI AZZERAMENTO

STUMENTI DI MISURA *'UNIVERSALI / COMPLESSI'*

ALTIMETRO E MACCHINA DI MISURA A COORDINATE

Strumenti di misura – Misure di *'DIMENSIONE'*

MISURA DI *'ERRORI DI GEOMETRIA'*

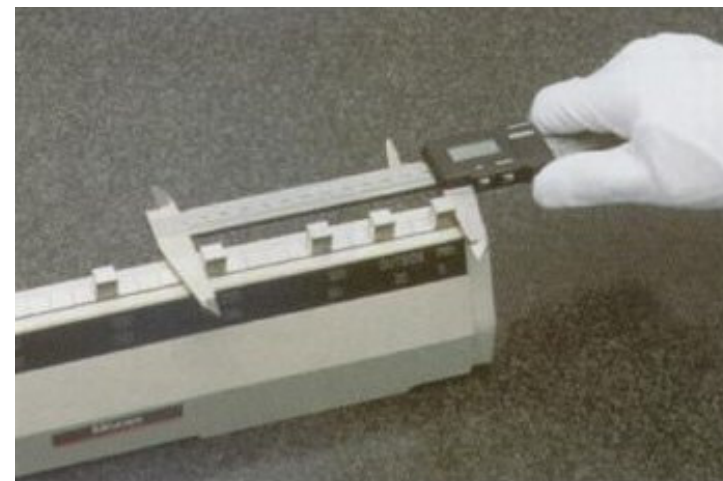
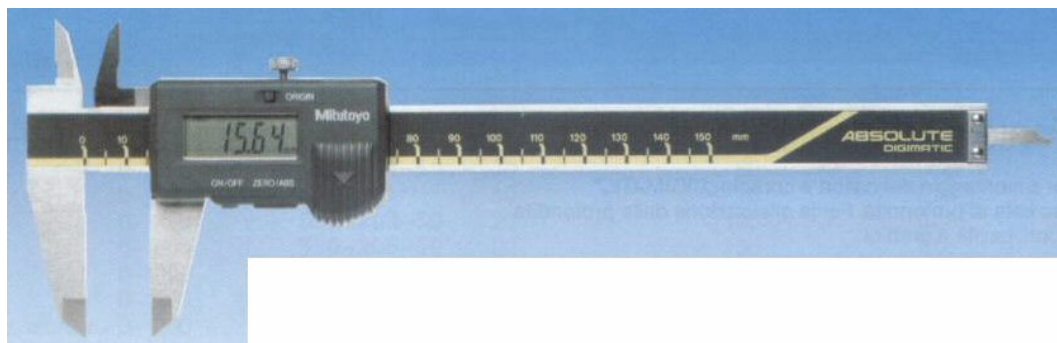
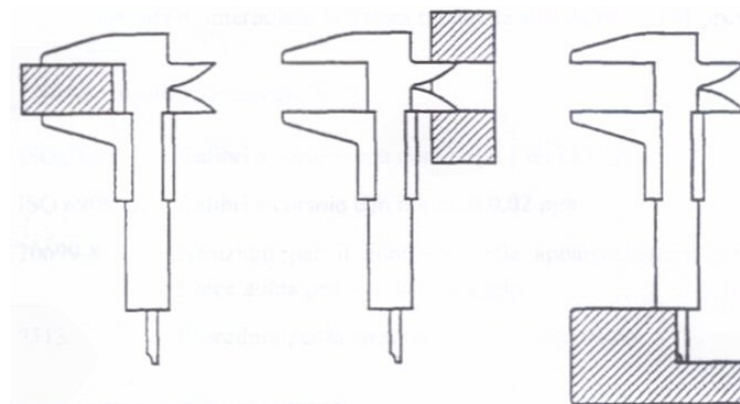
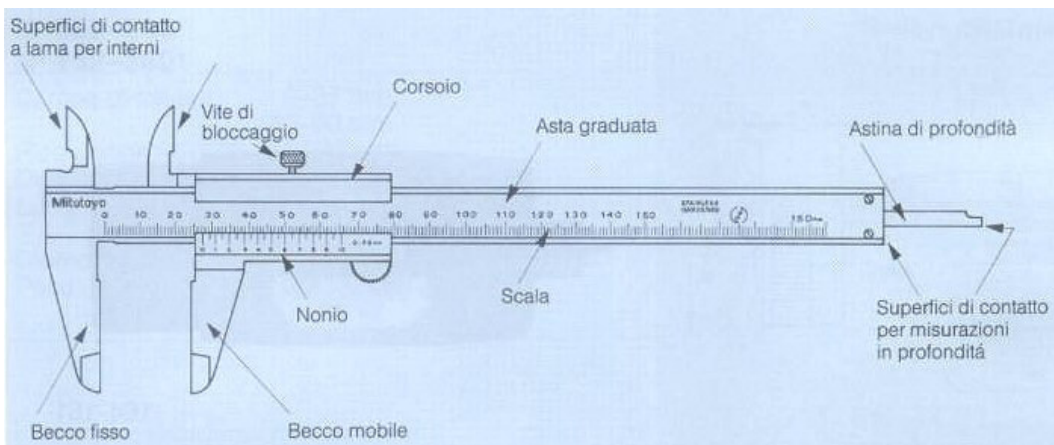
ROTONDIMETRO

MISURA DI *'RUGOSITA'*

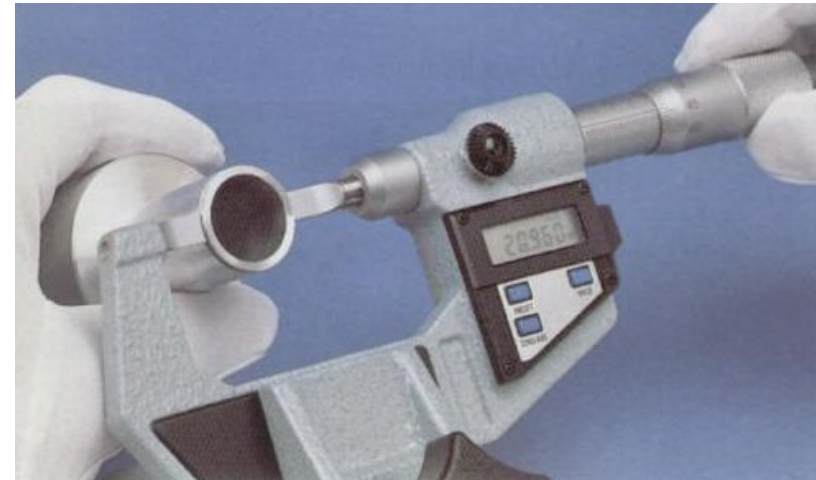
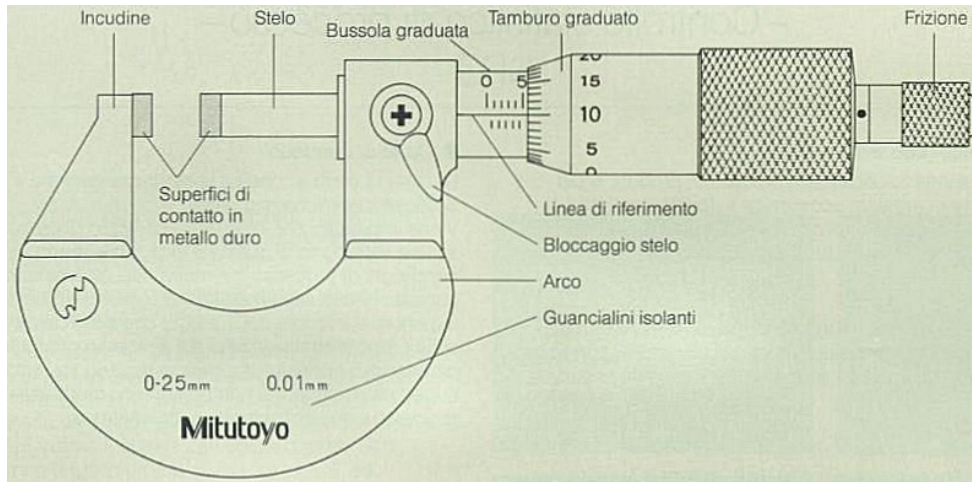
RUGOSIMETRO

MISURA DI *'DUREZZA'*

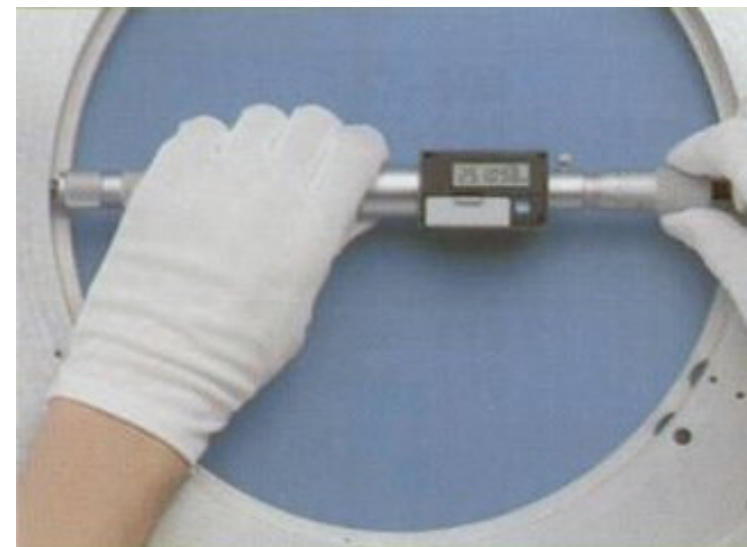
DUROMETRO



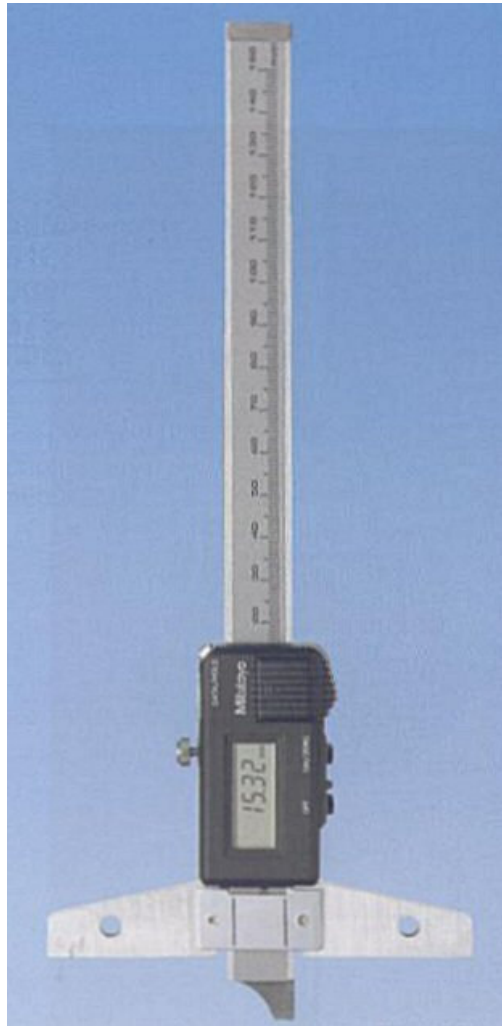
Calibro a corsoio



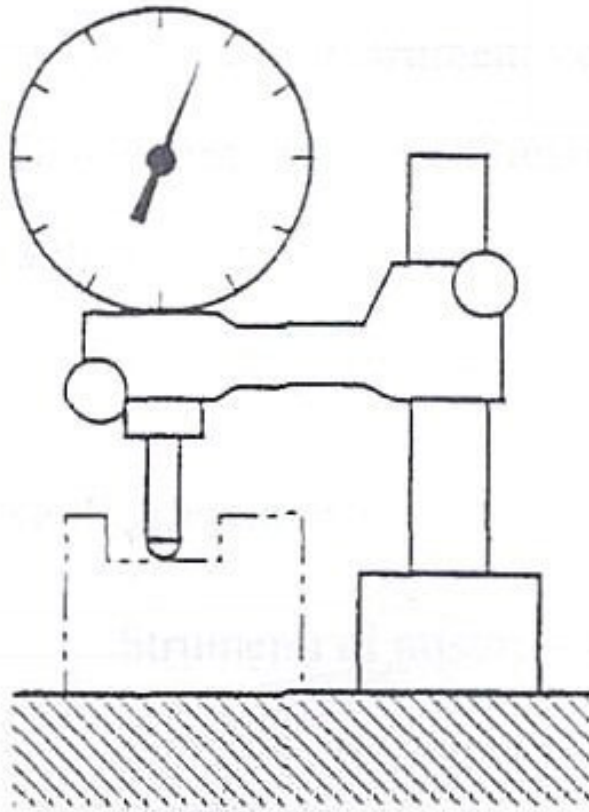
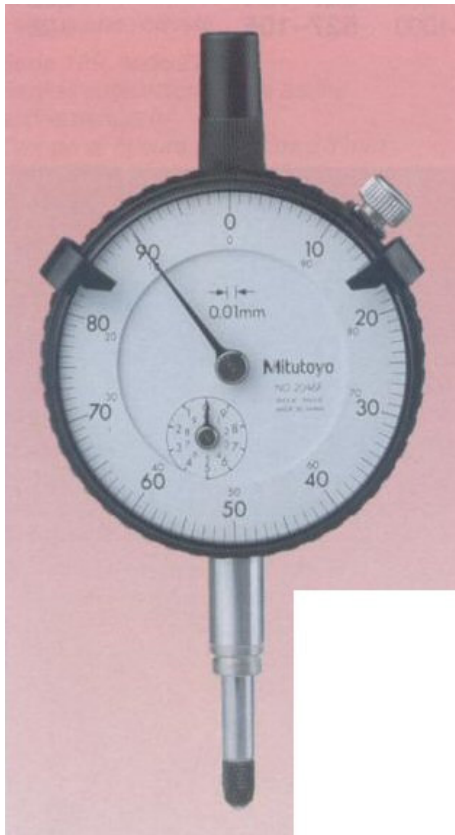
Micrometro per esterni



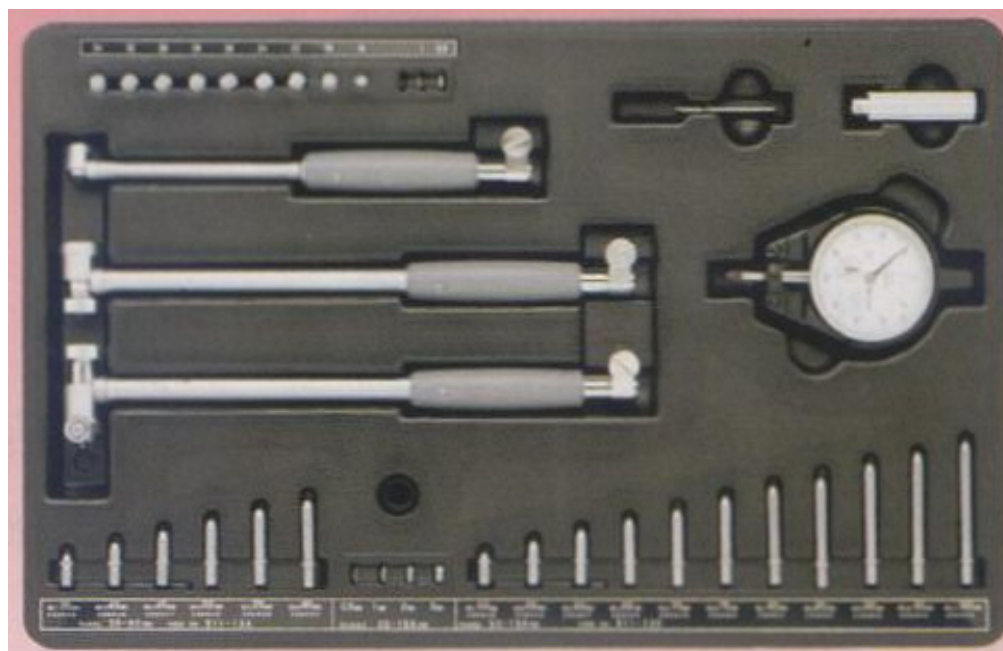
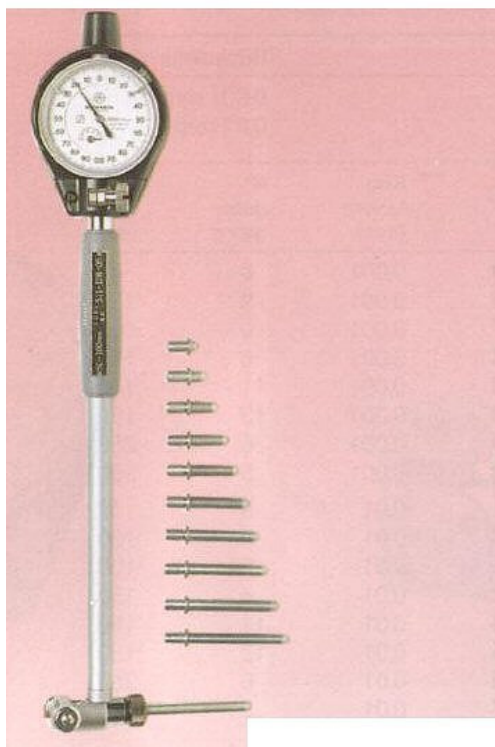
Micrometro per interni



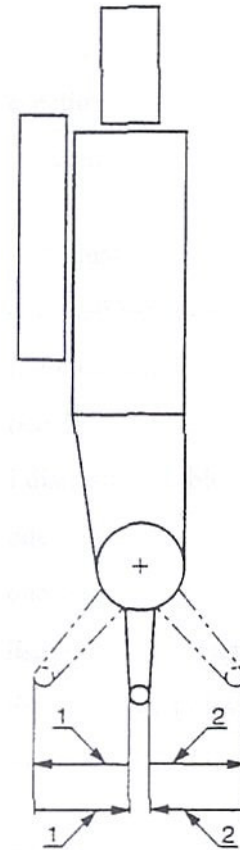
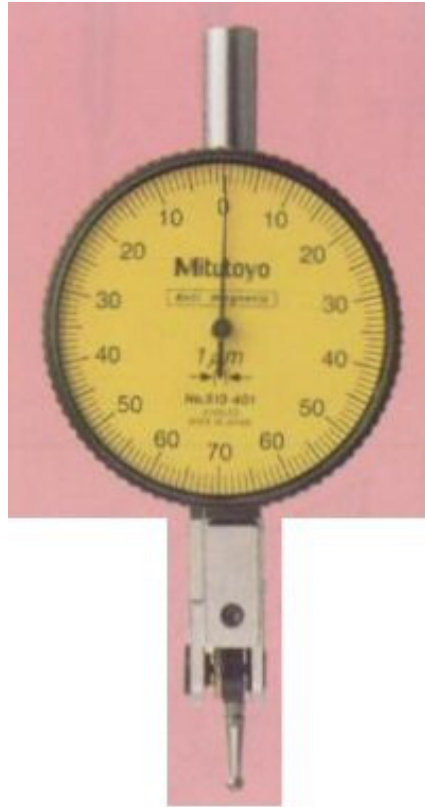
Misure di profondità – Calibro e micrometro



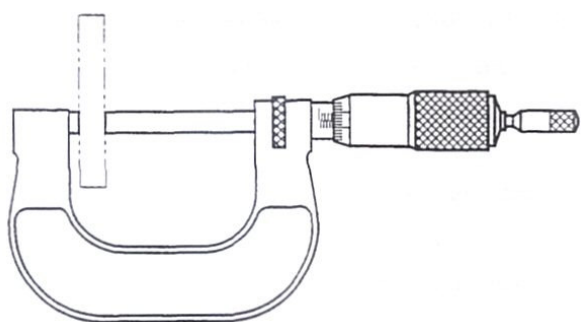
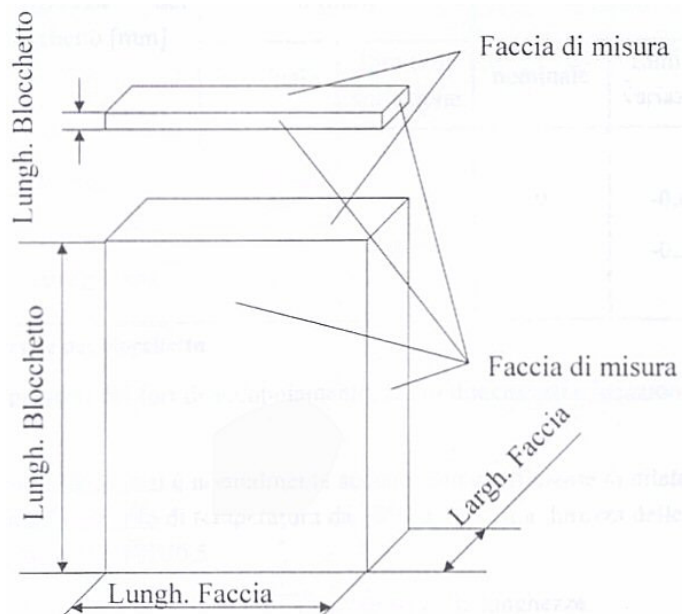
Comparatore e comparatore di profondità



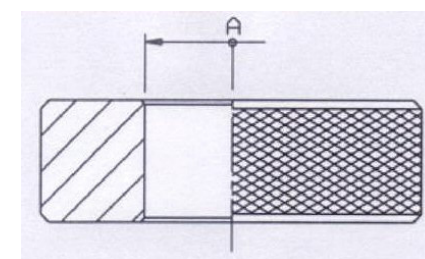
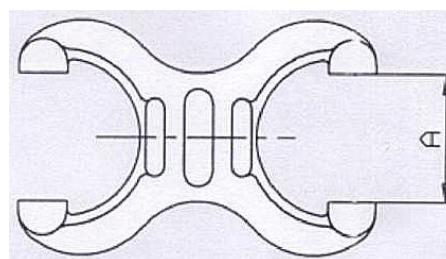
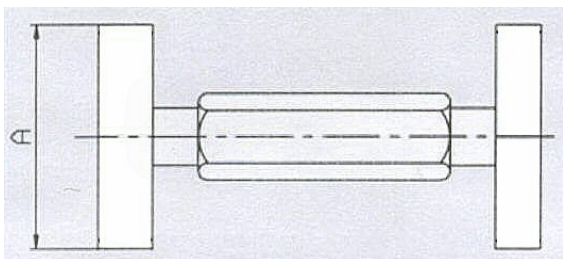
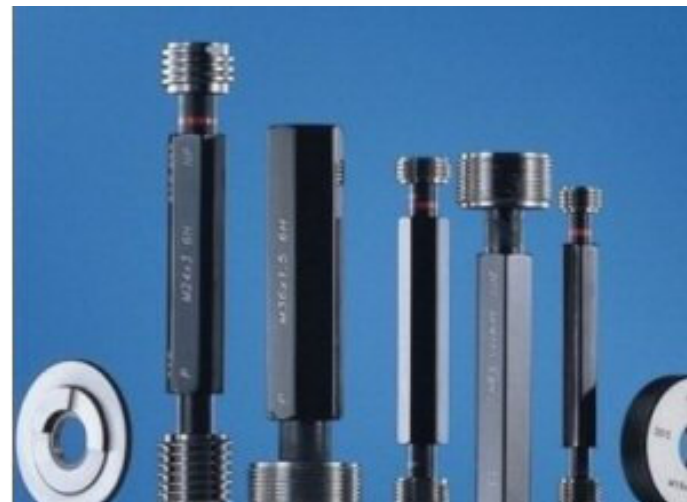
Alesametro



Tastatore



Calibri fissi – Blocchetti di riscontro



Calibri fissi – Tampone P-NP, forcilla P-NP e anello di azzeramento



Altimetro



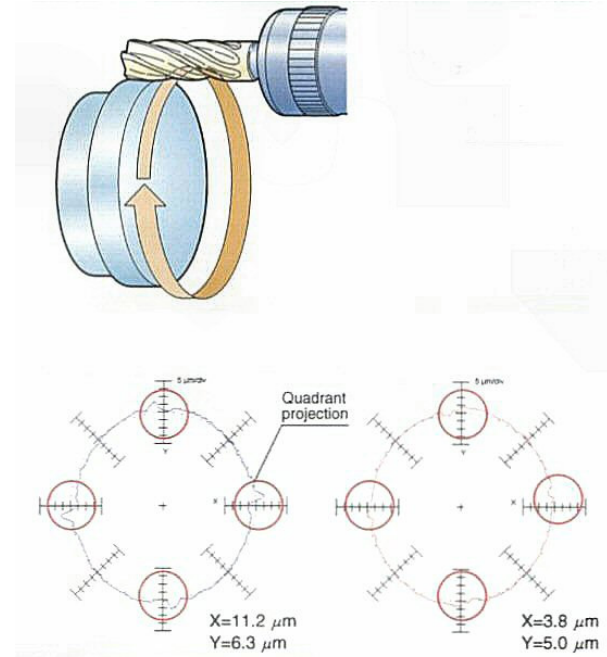
Precisione

$$E = (2,5 + 3,5 * L) \quad [\mu\text{m}]$$

L = Lunghezza di misura [m]



Macchina di misura a coordinate

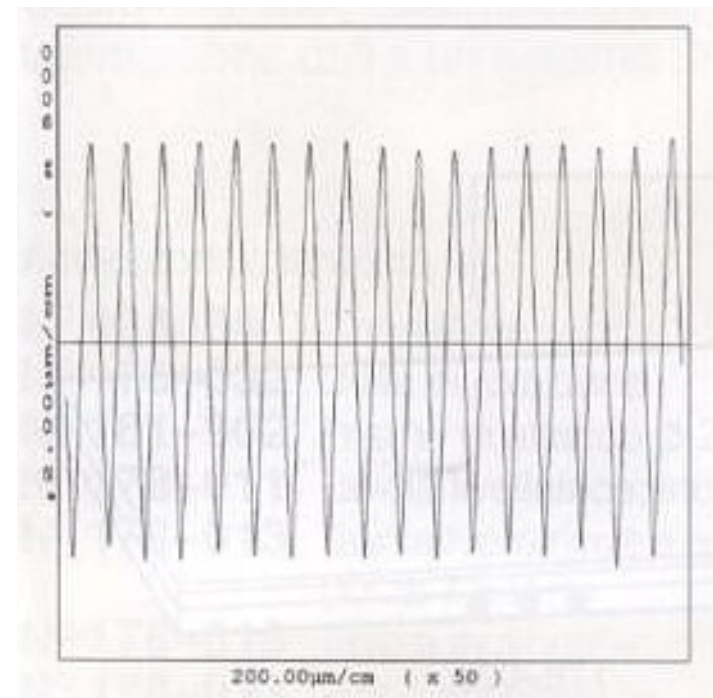


Rotondità (LSC)		
Rotondità (MIC)		
Rotondità (MCC)		
Rotondità (MZC)		
Diametro		

Concentricità		
Corsa totale		
Cilindricità		
Cilindricità (elica)		
Deviazione radiale		
Deviazione di spessore		
Planarità		
Parallelismo		

Perpendicolarità		
Rettilinearità		
Deviazione radiale		
Concentricità		
Coassialità		
Oscillazione sul raggio		
Oscillazione sul piano		

Rotondimetro



Rugosimetro



Durometro

CONTROLLO DURANTE IL PROCESSO DI PRODUZIONE

CONTROLLO AL 100 %

CONTROLLO A CAMPIONE

CONTROLLO STATISTICO DI PRODUZIONE (SPC)

CONTROLLO FINALE DI PRODUZIONE

CONTROLLO AL 100 %

CONTROLLO A CAMPIONE

CONTROLLO STATISTICO DI PRODUZIONE (SPC)

Valore Medio

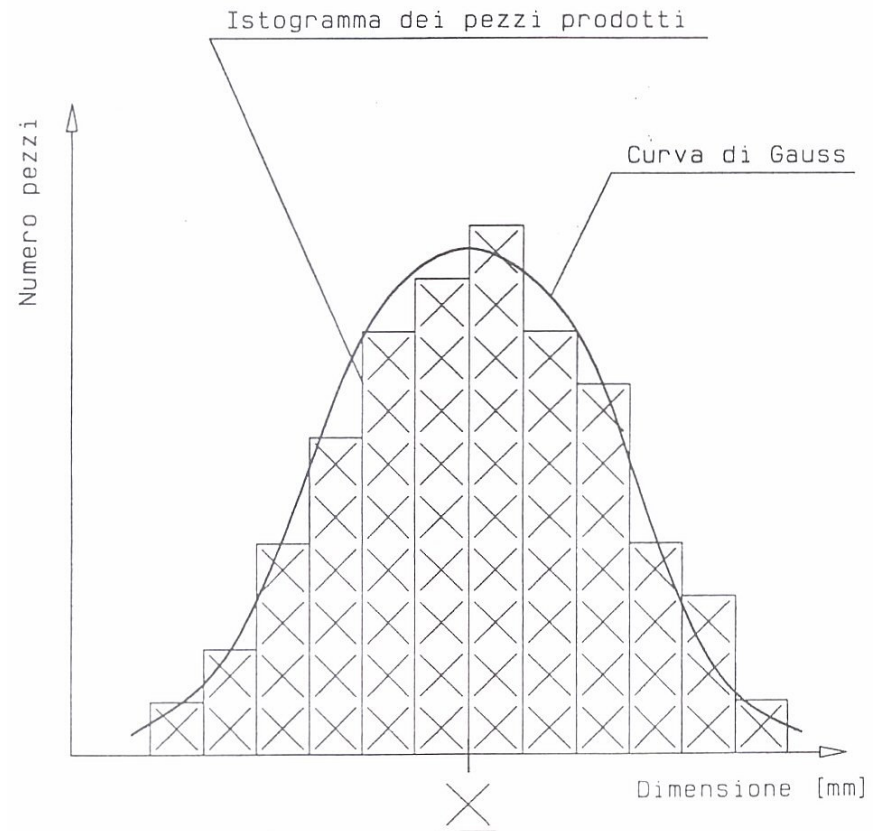
$$\underline{X} = (X_1 + X_2 + \dots + X_N) / N$$

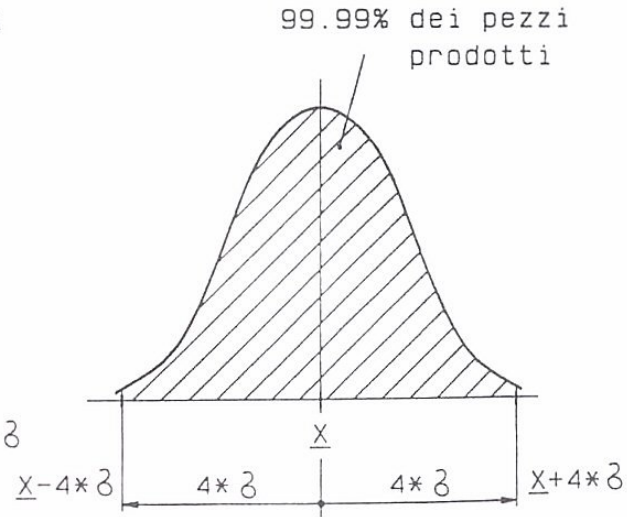
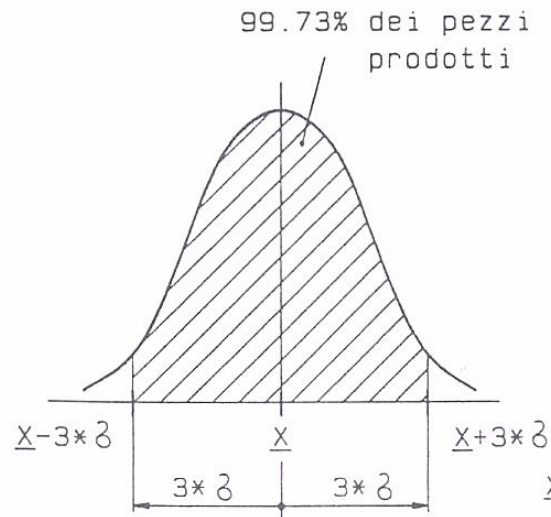
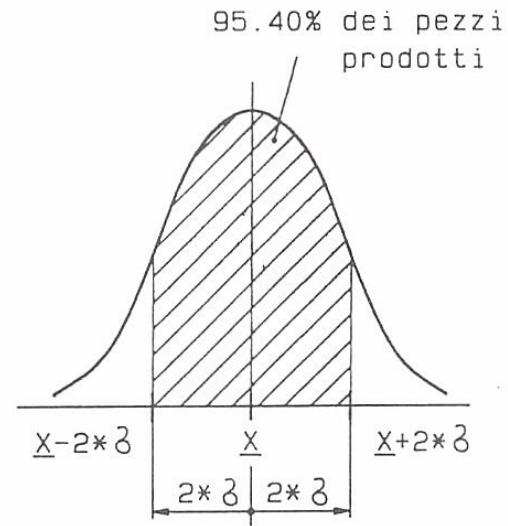
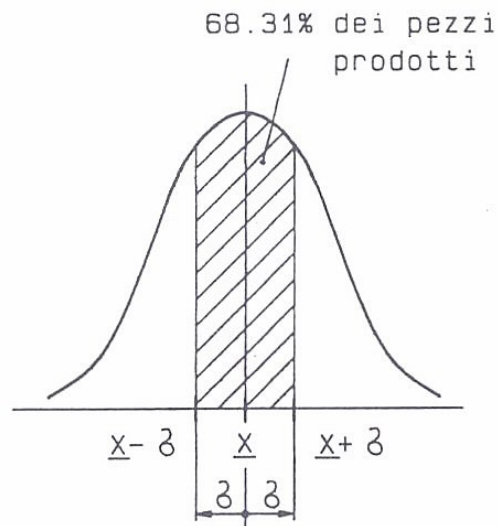
Range

$$R = (X_{\text{MAX}} - X_{\text{MIN}})$$

Varianza

$$\sigma^2 = (X_1 - \underline{X})^2 + (X_2 - \underline{X})^2 + \dots + (X_N - \underline{X})^2 / (N - 1)$$

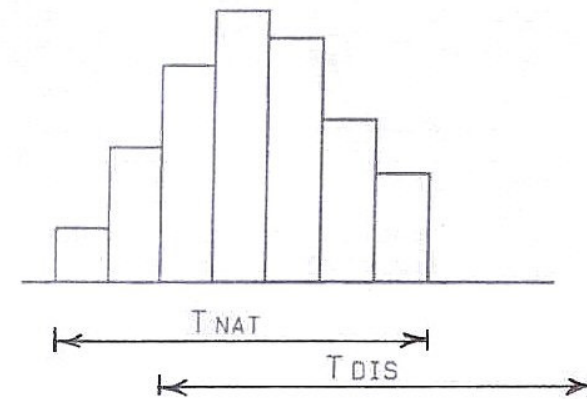
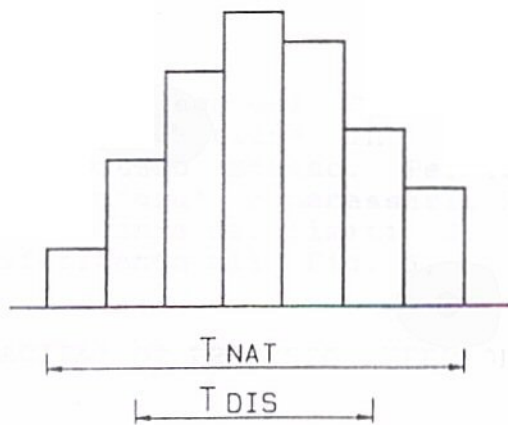
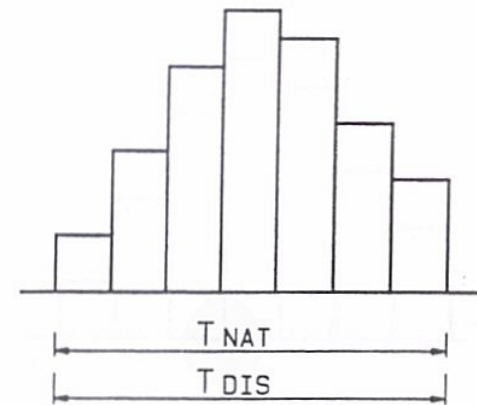
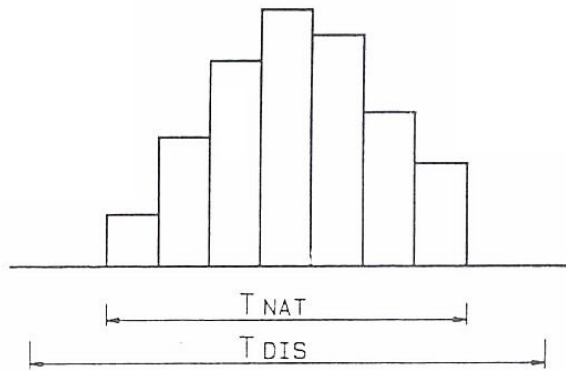




Statistica – Area sottesa dalla curva di GAUSS

Tolleranza Naturale

$$T_{\text{NAT}} = 6 * \sigma$$



Limiti di controllo per il 'VALORE MEDIO'

$$LCL_X = \bar{X} - K_1 * \bar{R}$$

$$UCL_X = \bar{X} + K_1 * \bar{R}$$

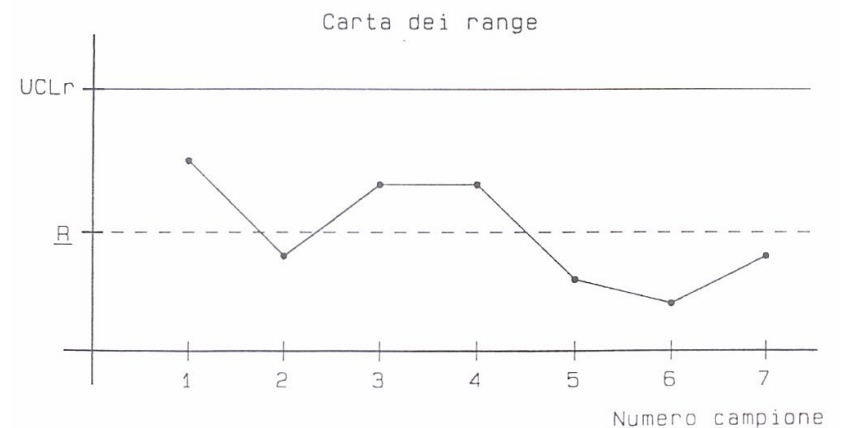
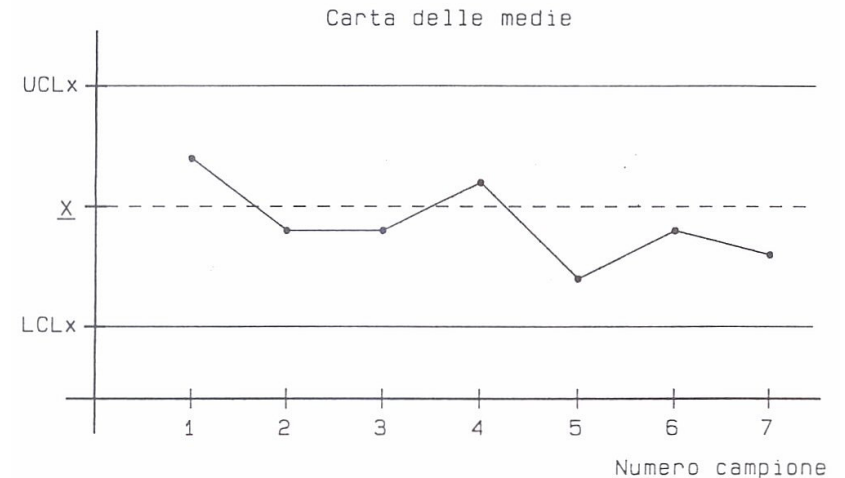
con $K_1 = 0,577$ per campioni di numerosità pari a 5

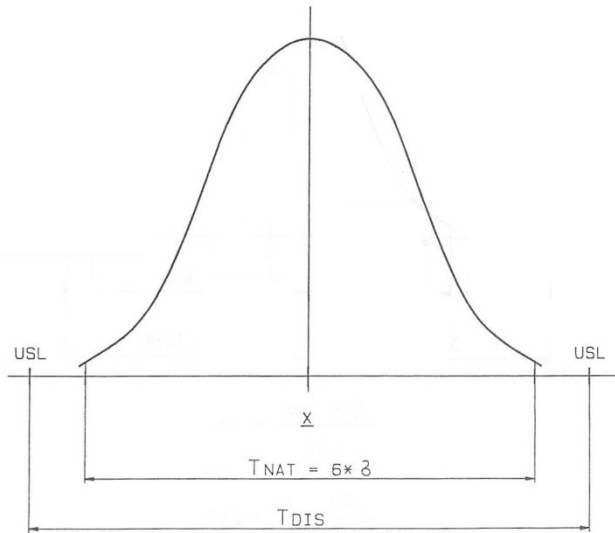
Limiti di controllo per il 'RANGE'

$$LCL_R = 0$$

$$UCL_R = K_2 * \bar{R}$$

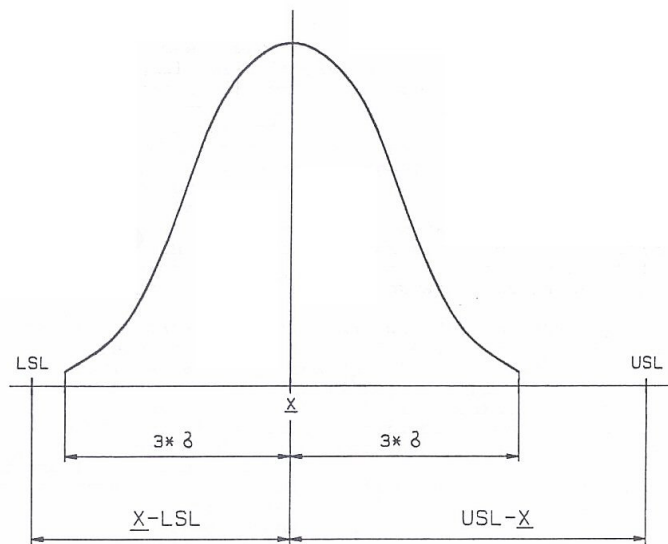
con $K_2 = 2,114$ per campioni di numerosità pari a 5





Indice di capacità di processo CP

$$C_P = T_{DIS} / T_{NAT} = T_{DIS} / (6 * \sigma)$$



Indice di capacità di processo 'SUPERIORE'

$$C_{PU} = (USL - \bar{X}) / (3 * \sigma)$$

Indice di capacità di processo 'INFERIORE'

$$C_{PL} = (\bar{X} - LSL) / (3 * \sigma)$$

Indice di capacità di processo CP_K

$$C_{PK} = \text{MIN} (C_{PU}, C_{PL})$$