Production and Operations Management/Gestão da Produção e Operações
2022/2023

FORMULAS SHEET/FORMULÁRIO

Inventory Management/Gestão de Stocks

EOQ

$Q = \sqrt{\frac{2DS}{H}}$; N = D/Q ; ROP = $d \times L$; $D \times T = Q$

$$TC = \frac{Q}{2} \times H + \frac{D}{Q} \times S + P \times D$$

POQ/QEF

$$Q = \sqrt{\frac{2DS}{H(1-\frac{d}{p})}}$$

$$TC = \frac{Q}{2}\ (1 - \frac{d}{p}) \times H + \frac{D}{Q} \times S + P \times D$$

$t_1 \times p = Q$; $t_2 \times d = M$; $T = t_1 + t_2 = Q/D$

$$I_{máx} = M = Q(1 - \frac{d}{p})$$

Probabilistic Models/Modelos probabilísticos

$$SS = Z_\alpha \sigma_{dLT}$$

$$ROP = \mu_{LT} \times \mu_d + SS$$

$$ROP = LT \times \mu_d + SS$$

$$ROP = \mu_{LT} \times d + SS$$

$$\sigma_{dLT} = \sqrt{\mu_d^2 \times \sigma_{LT}^2 + \mu_{LT} \times \sigma_d^2}$$

$$\sigma_{dLT} = \sqrt{LT} \times \sigma_d$$

$$\sigma_{dLT} = \sqrt{d^2 \times \sigma_{LT}^2}$$

$\alpha = P(X > ROP)$
$= \text{probability of stockout}$

$$TC = \left(\frac{Q}{2} + SS\right) \times H + \frac{D}{Q} \times S + P \times D$$

Project Management/Gestão de Projetos

EF = ES + Activity time = ES + duração da atividade

LS = LF – Activity time = LF - duração da atividade

Slack/Folga = LS – ES or Slack /Folga = LF– EF

Custo de esmagamento por período de tempo =
Crash cost per period = $\frac{CC - NC}{NT - CT}$

Expected activity time = Duração esperada = t = $\frac{a + 4m + b}{6}$

Variância da duração =
=Variance of activity completion time = $\left[\frac{(b-a)}{6}\right]^2$

Statistical Process Control/Controlo Estatístico do Processo

$UCL_{\bar{X}} = \bar{\bar{X}} + A_2 \times \bar{R}$ $LCL_{\bar{X}} = \bar{\bar{X}} - A_2 \times \bar{R}$ $CL_{\bar{X}} = \bar{\bar{X}}$ $UCL_R = D_4 \times \bar{R}$; $LCL_R = D_3 \times \bar{R}$ $CL_R = \bar{R}$ $C_{pk} = \min(C_{pki}; C_{pks})$ $C_p = \frac{USL - LSL}{6 \times \sigma}$ $C_{pki} = \frac{\mu - LSL}{3 \times \sigma}$ e $C_{pks} = \frac{USL - \mu}{3 \times \sigma}$	$UCL_c = \bar{c} + 3 \times \sqrt{\bar{c}}$ $LCL_c = \bar{c} - 3 \times \sqrt{\bar{c}}$ $CL_c = \bar{c}$ $UCL_p = \bar{p} + 3 \times \sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$ $LCL_p = \bar{p} - 3 \times \sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$ $CL_p = \bar{p}$

Capacity and Constraint Management/Gestão da Capacidade e Restrições

$$\text{Utilization/Utilização} = \frac{\text{Atual Output}}{\text{Design Capacity}} = \frac{\text{Output Atual}}{\text{Capacidade desenhada}} =$$

$$\frac{\text{Efficiency}}{\text{Eficiência}} = \frac{\text{Atual Output}}{\text{Effective Capacity}} = \frac{\text{Output Atual}}{\text{Capacidade Efetiva}} \qquad \frac{\text{Capacity}}{\text{capacidade}} = \frac{1}{\text{Cycle time}} = \frac{1}{\text{Tempo de ciclo}}$$

Waiting Line Models/Modelos de filas de espera

$$L_q = \lambda \times W_q \;;\quad L_S = \lambda \times W_S \;;\quad L_S = L_q + \lambda/\mu \;;\quad W_S = W_q + 1/\mu$$

M/M/1

$$L_q = \frac{\lambda^2}{\mu(\mu-\lambda)} \;;\; L_S = \frac{\lambda}{\mu-\lambda} \qquad W_q = \frac{\lambda}{\mu(\mu-\lambda)} \;;\; W_S = \frac{1}{\mu-\lambda}$$

$$\rho = \frac{\lambda}{\mu} \;;\quad P_0 = 1 - \rho \quad P_n = P_0 \times \left(\frac{\lambda}{\mu}\right)^n \qquad P(n > k) = \rho^{k+1}$$

M/M/S

$$P_0 = \frac{1}{\left[\sum_{n=0}^{S-1} \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n\right] + \frac{(\lambda/\mu)^S}{S!} \times \frac{S\mu}{S\mu-\lambda}} \; (S\mu > \lambda) \qquad Lq = \frac{\lambda \times \mu \times \left(\frac{\lambda}{\mu}\right)^S}{(S-1)!(S\mu-\lambda)^2} P_0 \qquad \rho = \frac{\lambda}{S\mu}$$

$$P_n = \frac{\left(\frac{\lambda}{\mu}\right)^n}{n!} P_0 \;\; (n \le S) \qquad P_n = \frac{\left(\frac{\lambda}{\mu}\right)^n}{S!S^{n-S}} P_0 \;\; (n > S)$$

M/D/1

$$L_q = \frac{\lambda^2}{2\mu(\mu-\lambda)};$$

$$W_q = \frac{\lambda}{2\mu(\mu-\lambda)} \qquad \rho = \frac{\lambda}{\mu}$$

M/M/1/N – Finite population/População finita

$$\bar{\lambda} = \sum_{n=0}^{N-1}(N-n)\lambda P_n = \lambda(N-L)$$

$$L = L_q + \frac{\bar{\lambda}}{\mu}$$

$$L_q = \sum_{n=1}^{\infty}(n-1)P_n = N - \frac{\lambda + \mu}{\lambda}(1-P_0)$$

$$W = W_q + \frac{1}{\mu} = \frac{L}{\bar{\lambda}}$$

$$P_n = \begin{cases} \frac{N!}{(N-n)!} \times \left(\frac{\lambda}{\mu}\right)^n \times P_0 & se\ n = 1,2,3 \ldots \\ 0 & se\ n > N \end{cases}$$

$$P_0 = 1 / \sum_{n=0}^{N}\left[\frac{N!}{(N-n)!} \times \left(\frac{\lambda}{\mu}\right)^n\right]$$

M/M/S/N – Finite population/População finita

$$\bar{\lambda} = \sum_{n=0}^{N-1}(N-n)\lambda P_n = \lambda(N-L)$$

$$L_q = \sum_{n=s}^{N}(n-S)P_n$$

$$P_0 = \frac{1}{\left[\sum_{n=0}^{S-1}\left[\frac{N!}{(N-n)!\,n!} \times \left(\frac{\lambda}{\mu}\right)^n\right]\right] + \left[\sum_{n=S}^{N}\left[\frac{N!}{(N-n)!\,S!\,S^{n-S}} \times \left(\frac{\lambda}{\mu}\right)^n\right]\right]}$$

$$P_n = \begin{cases} \frac{N!}{(N-n)!\,n!} \times \left(\frac{\lambda}{\mu}\right)^n \times P_0, & se\ n = 1, \ldots S \\ \frac{N!}{(N-n)!\,S!\,S^{n-S}} \times \left(\frac{\lambda}{\mu}\right)^n \times P_0, & se\ n = S, \ldots N \\ 0, & se\ n > N \end{cases}$$

$$L = L_q + \frac{\bar{\lambda}}{\mu}$$

$$W = W_q + \frac{1}{\mu} = \frac{L}{\bar{\lambda}}$$

$$\rho = \frac{\bar{\lambda}}{S\mu}$$

Scheduling/Sequenciamento

$$CR = \frac{Due\ Date - Today's\ date}{Work(lead)\ time\ remaining}$$

$$= \frac{Data\ prometida - Data\ actual}{Número\ de\ dias\ de\ trabalho}$$

Utilization/Utilização =

$$= \frac{Total\ job\ work\ time}{Total\ flow\ time}$$

$$= \frac{Tempo\ total\ de\ trabalho}{Soma\ flow\ time}$$

Average completion time/ Tempo médio de conclusão

$$= \frac{Total\ Flow\ Time}{Number\ of\ jobs} = \frac{Soma\ Flow\ Time}{Número\ de\ trabalhos}$$

Average job lateness / Atraso médio

$$= \frac{Total\ late\ days}{Number\ of\ jobs} = \frac{Soma\ Flow\ Time}{Número\ de\ trabalhos}$$

Average number of jobs in the system /
Número médio de trabalhos no sistema **=**

$$\frac{Total\ flow\ time}{Total\ job\ work\ time} = \frac{Soma\ flow\ time}{Tempo\ total\ de\ trabalho}$$

The Normal Distribution

Cumulative Standard Table

$P(Z \leq z) = \Phi(z)$

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990

α	0.400	0.300	0.200	0.100	0.050	0.025	0.020	0.010	0.005	0.001
Z_α	0.253	0.524	0.842	1.282	1.645	1.960	2.054	2.326	2.576	3.090
$Z_{\alpha/2}$	0.842	1.036	1.282	1.645	1.960	2.240	2.326	2.576	2.807	3.291

Factors for computing Control Chart Limits/Fatores para o cálculo dos limites de controlo

Sample size/Dimensão da amostra n	A_2	d_2	D_3	D_4
2	1.881	1.128	0	3.267
3	1.023	1.693	0	2.574
4	0.729	2.059	0	2.282
5	0.577	2.326	0	2.114
6	0.483	2.534	0	2.004
7	0.419	2.704	0.076	1.924
8	0.373	2.847	0.136	1.864
9	0.337	2.97	0.184	1.816
10	0.308	3.078	0.223	1.777
11	0.285	3.173	0.256	1.744
12	0.266	3.258	0.283	1.717
13	0.249	3.336	0.307	1.693
14	0.235	3.407	0.328	1.672
15	0.223	3.472	0.347	1.653
16	0.212	3.532	0.363	1.637
17	0.203	3.588	0.378	1.622
18	0.194	3.64	0.391	1.608
19	0.187	3.689	0.403	1.597
20	0.18	3.735	0.415	1.585
21	0.173	3.778	0.425	1.575
22	0.167	3.819	0.434	1.566
23	0.162	3.858	0.443	1.557
24	0.157	3.895	0.451	1.548
25	0.153	3.931	0.459	1.541