

40 Inventive Principles in Quality Management

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The founder of TRIZ, Genrich Altshuller, discovered forty patterns of inventive solutions, known as 40 Inventive Principles, extracting them from technical patents. It was found further that 40 Principles are applicable not only for every technical field, including architecture, computer software, microelectronics, food production, but also for non-technical spheres - biology, agriculture, business, management, marketing, social relations, pedagogy, etc. [1-10]. All referenced examples demonstrate that 40 Principles are fundamental, universal and powerful instruments of human creativity. Apparently, the examples of 40 Principles may be found in communication, mass media, literature, art, sport, medicine, justice, military, diplomacy, politics, and other spheres of mankind activity.

As one of the most effective problem solving techniques, TRIZ by definition inheres in the scope of Quality Management. The author collected numerous examples which demonstrate how extensively 40 Principles are used in the Quality Management area, including fields of quality standards, quality control, quality assurance, reliability, customer focus, supplier selection, project management, improvement teams, and so on. In some cases, the inversion of Principles [11] was found helpful.

Principle 1. Segmentation

A. Divide an object or system into independent parts.

- *Quality system elements.*
- *Customized marketing - complete market segmentation.*
- *Autonomous region sales centers.*
- *Sales splitting between customers.*
- *Four quality costs categories.*
- *Five steps of '5S' technique for continuous improvement: sort, set in order, shine, standardize, sustain.*
- *Eight steps of '8D' problem solving technique.*

B. Make an object or system easy to disassemble.

- *Project team.*
- *Concurrent engineering team.*
- *Process improvement and problem solving teams.*
- *Material Review Board.*

C. Increase the degree of fragmentation or segmentation.

- ***Break down strategic quality goals into tactical goals.***
- ***Quality goals and objectives deployment.***
- ***Mass customization - each customer is a market.***
- ***Scientific management - breaking down work into simple, repetitive tasks.***
- ***Project milestones.***
- ***Work breakdown structure (PERT/Gantt) for projects.***
- ***Quality costs breakdown.***
- ***Cause and effects diagram.***
- ***Affinity diagram - breaking down complicated issues into easier to understand categories and patterns.***
- ***Tree diagram.***
- ***FMEA, FMECA, FTA.***
- ***Pareto diagram categories.***
- ***Histogram intervals.***
- ***Stratified sampling for heterogeneous population.***

Principle 2. Taking out

A. Separate an interfering part or property from an object or system, or single out the only necessary part or property.

- ***External accredited body approval.***
- ***External laboratory testing.***
- ***Supplier selection.***
- ***Outsourcing.***
- ***Lean manufacturing - elimination of non-value added activities.***
- ***Containment action (D3 from 8D).***
- ***Root cause analysis (D4 from 8D).***
- ***Analysis of special cause of variation.***
- ***Removal of defective parts at screening inspection.***
- ***Segregation of non-conformant product, material, equipment.***
- ***Cluster analysis - distill qualitative customer feedback into quantitative data.***
- ***Separate problem from people.***

- *'Drive out fear' (W. E. Deming).*
- *Make quality audit function independent.*
- *Discrete personal interviews, reviews, etc.*

Principle 3. Local quality

A. Change an object or system structure from uniform to non-uniform, change an external environment (or external influence) from uniform to non-uniform.

- *Strength, Weakness, Opportunity and Threat (SWOT) analysis.*
- *Develop strategy for each market segment.*
- *Design for specific market niches.*
- *Use different (individual) marketing approach, advertising and promotions for each customer sector.*
- *Customize marking, packaging, labeling, etc.*
- *Benefit best customers.*
- *Business and quality goals prioritization.*
- *Unequal resource allocation.*
- *Individual budgets for different departments.*
- *Pareto principle of unequal distribution.*
- *'Vital few and trivial many' concept (J.M.Juran).*
- *Prioritize projects through the use of gap analysis, Pareto analysis, etc.*
- *Weight importance of customer needs in Quality Functional Deployment (QFD).*
- *Three levels of problem criticality: critical, major, minor.*
- *Classification of product characteristics and defects: critical, major, minor.*
- *Identify non-random patterns at trend analysis.*
- *Identify non-random pattern of variation (special cause) at SPC.*
- *Quantify customer preferences for product features at forced allocation survey.*

B. Make each part of an object or system function in conditions most suitable for its operation.

- *Locate distribution centers near to customers.*
- *Match personality types to the task to be performed.*
- *Educational modules - different in content and duration for different organizational levels.*

C. Make each part of an object or system fulfill a different and useful function.

- *Organizational division by function rather than product.*
- *Hire different specialists for different functions.*

Principle 3 (inverted). Generic quality

- *Mass marketing - market with no segmentation.*
- *Census instead of sampling survey.*
- *Random sampling.*
- *Random pattern of variation (common cause) at SPC.*
- *Audit randomly selected procedures.*
- *Random access quality data storage.*

Principle 4. Asymmetry

A. Change the shape of an object or system from symmetrical to asymmetrical.

B. If an object or system is asymmetrical, change its degree of asymmetry.

- *Use asymmetry for mismatching at mistake-proofing (Poka-Yoke).*
- *Asymmetrical statistical distributions.*
- *One-tail Student's test.*
- *Process performance index C_{pk} as a measure of parameter distribution asymmetry around the target.*

Principle 4 (inverted). Symmetry

- *Symmetrical normal distribution.*
- *Two-tail Student's test.*

Principle 5. Merging

A. Bring closer together (or merge) identical or similar objects, assemble identical or similar parts to perform parallel operations.

- *Transcontinental corporations.*
- *Business partnership, alliance, merging.*
- *Bring customers and suppliers into design loop.*
- *Professional associations.*
- *Quality function - collection of activities.*

- *As a project manager - develop network of alliances that reach all project stakeholders.*
 - *Unanimous concurrence of all MRB members at decision of nonconforming material acceptance.*
 - *'Break down barriers between departments' (W.E.Deming).*
 - *Consensus style decision making at Theory Z management.*
 - *5S technique for continuous improvement.*
 - *8D problem solving technique.*
 - *Team approach at problem solving (D1 from 8D).*
 - *Bring collective judgment to project problems and opportunities at team meetings.*
 - *Storyboarding - merging both creative and analytical thinking.*
 - *Merged categories and patterns at affinity diagram.*
- B. Make operations contiguous or parallel; bring them together in time.
- *Concurrent engineering.*
 - *Use PERT/Gantt chart for project management.*
 - *Institute parallel processes for cycle time reduction.*
 - *Groupware: mail, e-mail, Intranet, meetings, phone and video conferencing, etc.*

Principle 6. Universality

- A. Make an object or system perform multiple functions; eliminate the need for other parts.
- *Awareness of universality and integration as global marketing and business driving forces.*
 - *Facilitate skill diversification at matrix organization.*
 - *Hire multi-skilled personnel for complex jobs.*
- B. Use standardizes features.
- *International standards.*
 - *Market based cost standards.*
 - *Company procedures.*
 - *Product and process specifications.*
 - *Work instructions and workmanship standards.*
 - *Measurement, inspection and test equipment calibration versus national standards.*
 - *Material specifications.*

- *Specifications for incoming, in-process and final quality inspection.*
- *Specifications for functional, mechanical and environmental reliability testing.*
- *Standard record forms.*
- *Templates.*
- *Interchangeable work-force.*

Principle 6 (inverted). Specialization

- *In-depth skill development at hierarchical organization.*

Principle 7. Nesting

A. Place one object inside another; place each object, in turn, inside the other.

- *Hierarchy of ISO 9000 standards - 9001 embraces 9002 which in turn embraces 9003.*
- *Organization structure - several levels with several people within each organizational unit.*
- *Maslow's hierarchy of employee needs - basic, environment, simple individual, complex individual, transcendent.*
- *Hierarchy of customer expectations - basic, expected, desired, unanticipated.*
- *Market niches for new products.*
- *Store-in-store.*
- *Match personalities when assembling a team.*

B. Make one part pass through a cavity in the other.

- *Allow anyone in organization to communicate directly to any higher level.*
- *Expose traditionally inward facing employees to external events.*

Principle 7 (inverted). Mutual exclusivity

- *Mismatching at mistake-proofing (Poka-Yoke).*

Principle 8. Anti-weight

A. To compensate for the weight (downward tendency) of an object or system, merge it with other object or system that provide lift.

- *Business partnership, alliance, merger - combining unique strengths.*

- ***Company wide quality effort.***
- ***Breakthrough benchmarking.***
- ***Finding sponsors for a project.***
- ***As a project manager - get top management ongoing support.***
- ***Deliver management presentation before implementation of new initiative (e.g. quality cost system).***
- ***Hitch-hike on others ideas at brainstorming sessions.***

B. To compensate for the weight (downward tendency) of an object or system, make it interact with the environment (e.g. use global lift forces).

- ***Attach product marketing to customer and business driving forces (miniaturization, integration, universality, etc.).***

Principle 9. Preliminary anti-action

A. If it will be necessary to do an action with both harmful and useful effects, this action should be replaced with anti-actions to control harmful effects.

- ***Proactive approach.***
- ***Customer perception survey.***
- ***b-Site customer trials - provide information on reliability of high risk new product prior to distribution to general public.***
- ***Use PERT during project management - eliminate the need in crisis management.***
- ***Process decision program chart (PDCA) - planning countermeasures to avoid undesirable situations.***
- ***Failure analysis and prevention techniques - FMEA, FMECA, FTA.***
- ***Mistake-proofing (Poka-Yoke) - design for foreseeable unintended use.***
- ***Prevent wear-out failures by replacing short life parts.***

B. Create beforehand stresses in an object or system that will oppose known undesirable working stresses later on.

- ***Self-assessment, correction of non-conformances before starting ISO 9000 registration process.***
- ***Pre-award survey for potential supplier approval.***
- ***Robust design - design for reliability.***
- ***Design verification and validation.***
- ***Design reviews.***
- ***Prototype and pre-launch stages of Advanced Product Quality Planning (APQP) process.***
- ***Field reliability testing, reliability data package.***

- *Burn-in, voltage stress, thermal shock, etc. accelerated testing for sorting out parts prone to failure at infant mortality period.*
- *Process certification.*
- *Entrance applicant screening, testing, interview.*
- *Key process employee certification.*
- *Amplification of human senses at product control.*
- *Quality system audits.*
- *Indicate unfavorable trend or potential problem at audit report.*
- *Run and update anti-virus software.*

Principle 9 (inverted). Afterward anti-action

- *Post-project evaluations and reviews.*
- *Lost customers survey and analysis.*

Principle 10. Preliminary action

A. Perform, before it is needed, the required change of an object or system (either fully or partially).

- *Strategic business planning and programming.*
- *Strategic quality planning.*
- *Marketing research.*
- *Project pre-planning.*
- *Product pre-advertising.*
- *Concurrent engineering.*
- *Capability study.*
- *Preventive maintenance.*
- *Early Supplier Involvement (ESI).*
- *Procedure writing.*
- *Training and qualification.*
- *Timely supply of information.*

B. Pre-arrange objects such that they can come into action from the most convenient place and without losing time for their delivery.

- *Project PERT/Gantt chart.*
- *Process flow chart.*

- *Batch route card.*
- *Decrease setup time using Single Minute Exchange of Die (SMED) techniques.*
- *Just-In-Time (JIT) delivery concept.*
- *First Expired First Out (FEFO) storage concept.*
- *First In First Out (FIFO) storage and delivery concept.*
- *Prepare questionnaire before survey.*
- *Prepare quality audit checklist.*
- *Distribution agenda before meeting.*

Principle 11. Beforehand cushioning

A. Prepare emergency means beforehand to compensate for the relatively low reliability of an object or system.

- *Business interruption contingency planning.*
- *Back-up functions.*
- *Split sales between customers.*
- *Institute recovery system for response to customer complaint and conflict resolution.*
- *Redundancy.*
- *Troubleshooting.*
- *Project contingency planning.*
- *Emergency quality planning.*
- *Second source suppliers.*
- *Excess inventory.*
- *Back-up power generator.*
- *Back-up computer data.*

Principle 12. Equipotentiality

A. In a potential field, limit position changes (e.g. change operating conditions to eliminate the need to raise or lower objects in a gravity field).

- *For quality costs trend analysis - compare quality costs to proper measurement bases (dollars per unit of production, % of manufacturing cost, relation to net sales, etc.).*
- *Time weighted inflows and outflows at benefit-cost analysis.*

- ***Resource leveling at project management - smoothing peaks and valleys, minimizing effect of conflict in demand for the same resources, scheduling activities during slack periods.***
- ***Homogeneous customer sectors (clusters).***
- ***Homogeneous training groups.***
- ***Nominal group technique.***

Principle 13. Inverse

A. Invert the action(s) used to solve the problem (e.g. instead of cooling an object, heat it).

- ***'A people-building philosophy will make the program successful, a people-using philosophy will make the program fail' (K.Ishikawa).***
- ***Blame the process not the person.***
- ***Proactively encourage customers to complain.***

B. Make movable parts (or the external environment) fixed, and fixed parts movable.

- ***Overcome reluctance of dissatisfied customers to complain.***
- ***Pursue the full story from dissatisfied customers, get them to really talk.***
- ***Management By Walking Around (MBWA).***

C. Turn the object or system 'upside down'.

- ***Product-based vs function-based organization structure.***
- ***Upward vs downward communication flow.***
- ***Make survey and analysis of lost customers.***
- ***Provocation technique at brainstorming sessions - turn the problem upside down.***

Principle 14. Spheroidality

A. Instead of using rectilinear parts, surfaces, or forms, use curvilinear ones; change flat surfaces to spherical ones; parts shaped as a cube (parallelepiped) to ball-shaped structures.

- ***Rounded personalities provide customer service.***
- ***Smoothing technique for conflict resolution - emphasizing areas of agreement, de-emphasizing areas of disagreement, seeking a joint problem solving opportunity.***
- ***Deviation request procedure - formal method for circumventing the rules.***

B. Use rollers, balls, spirals, domes.

- ***Quality circle.***

- *Round-robin fashion of idea submission at nominal group technique.*
- C. Change from linear to rotary motion, use centrifugal forces.
- *Team leadership rotation.*
 - *Rolling forecast of customers purchase requirements.*
 - *Customer survey questionnaires circulation.*

Principle 14 (inverted). Linearity

- *Aspiration for steeper operating characteristic curve at sampling inspection.*

Principle 15. Dynamics

A. Allow (or design) the characteristics of an object, external environment, or process to change to be optimal or to find an optimal operating condition.

- *Address variation as a fact of life in external and internal environment.*
- *Adapt to highly competitive business environment.*
- *Adapt to dynamic customer wants, needs and expectations.*
- *Project management - ad hoc activity needed to effect change.*
- *'Project by project' approach (J.M.Juran).*
- *Optimum quality cost model.*
- *Engineering change procedure.*
- *Update documentation periodically.*
- *Adjust internal quality audits frequency.*
- *Adjust calibration schedule on the basis of results.*
- *As a project manager - identify team members who have the ability to adapt to a changing situation in which they report to multiply managers.*

B. Divide an object or system into parts capable of movement relative to each other.

C. If an object or system is rigid or inflexible, make it movable or adaptive.

- *Quality is a moving target.*
- *Flexible organization structure ('chaocracy').*
- *Flexible staff - use of temporary workers and overtime.*
- *Control charts, run charts, trend charts for displaying dynamic picture of process behavior.*
- *Continuous ranking change of jobs to be completed.*

Principle 15 (inverted). Statics

- *'Reduce variation' (W.E.Deming).*
- *Take no actions as the best choice in order not to tamper with an object or system.*
- *Awareness of organizational roadblocks for change.*

Principle 16. Partial or excessive actions

A. If 100 percent of an objective is hard to achieve using a given solution method then, by using 'slightly less' or 'slightly more' of the same method, the problem may be considerably easier to solve.

- *Under-promise and over-deliver to achieve customer satisfaction.*
- *Stretching internal versus external specification requirements.*
- *Safety margins.*
- *Use stretch goals and objectives for employees.*
- *Vital few categories at Pareto diagram.*
- *Tolerance - permitted range of deviation from standard.*
- *Measurement accuracy - indication of closeness to the true value.*
- *Accuracy of quality costs estimates (typically 85%).*
- *Acceptable Quality Level (AQL) - percent of defectives that is considered satisfactory as a process average.*
- *Waiver - written authorization to release product that does not conform to specified requirements.*
- *Compromise at conflict resolution.*

Principle 16 (inverted). All or nothing

- *'All or nothing' approach (W.E.Deming).*
- *'Zero defects' quality goal (P.B.Crosby).*
- *100% Inspection - visual, dimensions go/no-go, non-destructive.*
- *100% On-time delivery goal.*
- *'Six Sigma' quality goal.*

Principle 17. Another dimension

A. Move an object or system in two- or three-dimensional space.

- *Matrix (product vs function) organization structure.*

- *Matrix (project vs line) management system.*
 - *Multi-dimensional organization hierarchy charts.*
 - *Parallel structures (quality council, etc.).*
 - *Cross-functional collaboration at project management.*
 - *Multi-disciplinary cross-functional teams.*
 - *Multi-dimensional customer satisfaction surveys.*
 - *Interrelationship diagram.*
 - *Matrix diagram for FMEA, FTA, 8D Summary, DOE.*
 - *L, T, Y, X, C types of matrices.*
 - *House of quality (QFD).*
- B. Use a multi-story arrangement of objects instead of a single-story arrangement.
- *Multi-layers hierarchy at vertical organization.*
- C. Tilt or re-orient the object or system, lay it on its side.
- *Horizontal flow of work at project management.*
 - *Horizontal communication.*
 - *Shift from line to project management dominance in matrix organization and vice-versa - depending on prevailing market conditions.*
 - *Excursion technique at brainstorming sessions - approach to problem from a different angle.*
- D. Use 'another side' of a given area.
- *Commitment - internalizing the values of customer focus by all employees.*
 - *Organizational assessment - viewing organization from the other side - either directly or using external consultants.*
 - *Extensive two-way communication.*

Principle 17 (inverted). Decreased dimensionality

- *Flat organization structure advantage - fewer layers between leadership and customer.*

Principle 18. Mechanical vibration

A. Cause an object or system to oscillate or vibrate.

- *Frequently communicate in multiple modes.*

B. Increase its frequency (even up to the ultrasonic).

C. Use an object or system resonant frequency.

- ***Use strategic planning (policy deployment, Hoshin Kanri) to select right frequency and get organization resonating to accomplish breakthrough strategy.***

D. Use piezoelectric vibrators instead of mechanical ones.

E. Use combined ultrasonic and electromagnetic field oscillations. (Use external elements to create oscillation/vibration).

- ***Periodically re-energize continuous improvement initiatives ('enthusiasm injections').***
- ***Initiate third party external assessment.***
- ***Bring new-blood/new challenge into a team.***

Principle 19. Periodic action

A. Instead of continuous action, use periodic or pulsating actions.

- ***Shewhart - Deming PDCA cycle.***
- ***'Project by project' approach (J.M.Juran).***
- ***Project life cycle concept - most projects pass through similar phases from start to finish.***
- ***Periodical project reviews.***
- ***Payback period method - measure of project liquidity.***
- ***Batch manufacture - small customized series.***
- ***Multiple process runs.***
- ***Periodical in-process control, analysis, inspection.***
- ***Periodical reliability testing.***
- ***Periodical quality auditing, metrics, reporting.***

B. If an action is already periodic, change the periodic magnitude or frequency.

- ***Monthly and weekly feedback reporting instead of annual reviews.***
- ***Adjustable internal quality audits frequency.***

C. Use pauses between impulses to perform a different action.

- ***Perform preventive maintenance during vacations.***
- ***Conduct training during pauses in work.***
- ***Use slack time at PERT.***

Principle 20. Continuity of useful action

A. Carry on work continuously; make all parts of an object or system work at full load, all the time.

- ***'Constancy of purpose' (W.E.Deming).***
- ***'Continual survival at the marketplace' (TQM goal).***
- ***Long-term strategic business planning.***
- ***Long-term strategic quality planning - road map for directions of continuous improvement.***
- ***Quality control - preservation of status-quo.***
- ***Kaizen - continuous improvement.***
- ***Build customer retention.***
- ***Nurture customer loyalty.***
- ***Adapt to steady increasing customer expectations.***
- ***Be aware that satisfaction of customer needs is never ending challenge.***
- ***Introduce self-competing.***
- ***Create company brand and trademark.***
- ***Use stable and predictable historical perspective as a basis for establishing quality objectives.***
- ***Single source supplier advantages - long-term commitment, reduced variation.***
- ***Written procedures and specifications as perpetual coordination device.***
- ***Configuration control.***
- ***Traceability system.***
- ***Calibration - comparison against instrument with verified accuracy in order to promote consistency of measurement.***
- ***Life-long learning.***
- ***'Do it all over again' (P.B.Crosby).***

B. Eliminate all idle or intermittent actions or work.

- ***Resource leveling - smoothing peaks and valleys, minimizing effect of conflict in demand for the same resources, scheduling activities during slack periods.***
- ***Streamline both internal and external setups to reduce total setup time (SMED).***
- ***Use multi-skilled bottleneck functions to improve workflow.***
- ***Preventive and predictive maintenance.***

Principle 21. Skipping

A. Conduct a process, or certain stages (e.g. destructive, harmful or hazardous operations) at high speed.

- ***'Fast Cycle - Full Participation'* - method of involving the whole organization simultaneously and rapidly in a major change, such as reengineering.**
- ***Get through painful processes quickly (e.g. conflict resolution).***
- ***Promptly remove invalid or obsolete documents.***

Principle 22. "Blessing in disguise"

A. Use harmful factors (particularly, harmful effects of the environment or surroundings) to achieve a positive effect.

- ***Use customer complaints as opportunities for improvement.***
- ***Customers whose complaints are handled properly are more loyal than customers who never had a complaint.***

B. Eliminate the primary harmful action by adding it to another harmful action to resolve the problem.

- ***Eliminate fear of change by introducing fear of competition.***

C. Amplify a harmful factor to such a degree that it is no longer harmful.

- ***Reduce resource levels to such an extent that new ways of doing the job have to be discovered.***
- ***Apply burn-in, voltage stress, thermal shock, etc. accelerated testing for sorting out parts prone to failure at infant mortality period.***

Principle 22 (inverted). "Cursing in disguise"

- ***Absence of customer complaints may indicate lack of customer candor and unwillingness to share information.***
- ***Expenditures under project budget may serve as evidence of 'cutting corners'.***
- ***'Quality is everybody's job, but because it is everybody's job, it can become nobody's job' (A.V.Feigenbaum).***

Principle 23. Feedback

A. Introduce feedback (referring back, cross-checking) to improve a process or action.

- ***'C' (check) at PDCA cycle.***
- ***Management reviews.***
- ***Budget variance measurements.***

- ***Voice of the customer - survey, visit, report, focus group, interview, mail, feedback form, customer satisfaction checklist.***
- ***Customer complaints and suggestions system.***
- ***Product returns and field failures analysis system.***
- ***Product guarantees - provide feedback data on how products fail to meet customer needs.***
- ***Enlist customers into design process.***
- ***Ongoing feedback loop for project evaluation - schedule, technical objectives, strategic fit.***
- ***Periodical project reviews.***
- ***Prototype testing.***
- ***Periodical reliability testing.***
- ***Failure analysis - FMEA, FMECA, FTA.***
- ***b-Site customer trials.***
- ***Supplier surveys.***
- ***Supplier performance evaluation process.***
- ***Quality audits and reviews.***
- ***Corrective actions and follow-up.***
- ***Quality reporting and information system.***
- ***Annual employee reviews.***

B. If feedback is already used, change its magnitude or influence.

- ***Monthly, weekly and daily business reviews.***
- ***Monthly review of Hoshin Kanri process.***
- ***Continuous feedback communication at project management.***
- ***Test run for process parameters adjustment.***
- ***First article inspection.***
- ***Statistical Process Control (SPC).***
- ***Nonconforming product control system - monitoring, reporting and corrective actions.***
- ***Incoming, in-process and final quality inspection and testing.***
- ***Quality costs monitoring.***
- ***For making training program effective - feed back to employee meaningful measures of his performance.***

Principle 23 (inverted). Feedforward

- *'Predict and compare' (W.E.Deming).*
- *Long-term strategic business planning and programming.*
- *Strategic quality planning.*
- *Leadership vision.*
- *Marketing forecast.*
- *Anticipating customer future needs.*
- *Technology road map.*
- *Trend analysis.*
- *Predictability within limits as output of SPC.*
- *Reliability prediction.*
- *Anticipatory Failure Determination.*

Principle 24. Intermediary

A. Use an intermediary carrier article or intermediary process.

- *Third-party external quality auditing.*
- *External laboratory testing.*
- *Top management representative for quality system implementation and management.*
- *Change agent at reengineering.*
- *Region sales offices.*
- *Customer service, customer contact person.*
- *Intermediate customers - wholesaler, distributor, retailer.*
- *Export/import, transportation and delivery agencies.*
- *Facilitator at nominal group, brainstorming, problem solving team.*
- *Transfer calibration standard.*

B. Merge one object temporarily with another (which can be easily removed).

- *Implement interim containment action (D3 at 8D).*
- *Hire temporary employees.*
- *Introduce specialist to trouble-shooting/fire-fighting team.*
- *Hire consultant.*
- *Use impartial body during difficult negotiation.*
- *Use arbitrator for sensitive discussion.*

- *Introduce moderator to a focus group.*
- *Hitch-hike on others ideas at brainstorming sessions.*

Principle 24 (inverted). Direct contact

- *Management By Walking Around (MBWA).*

Principle 25. Self-service/Self-organization

A. Make an object or system serve itself by performing auxiliary helpful functions.

- *Self-benchmarking.*
- *Self-competing.*
- *Self-assessment.*
- *Self-auditing (internal quality audits and corrective actions system).*
- *Self-directed work team.*
- *Self-inspection.*
- *Self-improvement (process improvement teams).*

B. Use waste (or lost) resources, energy, or substances.

- *Re-hire retired workers for jobs where their experience is needed.*
- *Use scrapped or dummy parts for experiments.*
- *Re-cycle materials.*

Principle 26. Copying

A. Instead of an unavailable, expensive, or fragile object or system, use simpler inexpensive copies.

- *Use customer satisfaction as a measure of an organization's business well-being.*
- *Lead by example.*
- *Use Malcolm Baldrige National Quality Award criteria as model of excellence.*
- *Benchmark competitors.*
- *Benchmark similar projects in order to identify improvement opportunities.*
- *Design and process modeling.*
- *Rapid prototyping.*
- *Using reference at experiments.*

- **Quality tests - designed to approximate conditions at customer's application.**
 - **Quality metrics - any critical and useful performance measurement.**
- B. Replace an object or system with optical copies.
- **Using electronic database instead of paper records.**
 - **Numerical simulation - virtual business development, strategic planning modeling, etc.**
 - **Drawing conclusion about population on the basis of sampling statistics.**
 - **Video-conferencing instead of physical travel.**
- C. If optical copies are used, change to IR or UV. (Use an appropriate, out-of-the-ordinary illumination and viewing situation).
- **Evaluate customer satisfaction using multiple techniques.**
 - **Respond to perceived customer needs.**
 - **Use simulations, games, case-studies instead of lecture-style training.**

Principle 27. Cheap short-living objects

- A. Replace an expensive object with a multiple of inexpensive objects, compromising certain qualities (such as service life, for instance).
- **Subcontract non-core business.**
 - **Hire temporary employees for non-critical positions.**
 - **By no-brand equipment and materials for non-critical processes.**
 - **Use disposable miscellaneous and packaging materials.**

Principle 28. Mechanics substitution

- A. Replace a mechanical means with a sensory (optical, acoustic, taste or smell) means.
- B. Use electric, magnetic and electromagnetic fields to interact with the object or system.
- **Electronic communication.**
 - **Electronic data processing.**
 - **Electronic data transmission.**
 - **Electronic bar coding.**
 - **Electronic tagging.**
 - **Electronic voting.**
- C. Change from static to movable fields, from unstructured fields to those having structure.

- ***Force field analysis.***

Principle 29. Pneumatics and hydraulics

A. Use gas and liquid parts of an object or system instead of solid parts (e.g. inflatable, filled with liquids, air cushion, hydrostatic, hydro-reactive).

- ***Flexible (fluid) organization structure versus fixed hierarchical structure.***
- ***Liquidation of assets.***
- ***Introduction of 'breathing spaces' into contracts.***

Principle 30. Flexible shells and thin films

A. Use flexible shells and thin films instead of three-dimensional structures.

- ***Flat organization structure advantage - fewer layers between leadership and customer.***

B. Isolate the object or system from the external environment using flexible shells and thin films.

- ***Use 'trade secret' methods to separate company proprietary knowledge from general knowledge.***

Principle 31. Porous materials

A. Make an object or system porous or add porous elements (inserts, coatings, etc.).

B. If an object or system is already porous, use the pores to introduce a useful substance or function.

- ***Customer-facing layer of a company - porous membrane which filters information flow both into and out of the organization.***
- ***Improve internal communications by creating Intranet accessible by all hierarchical layers, giving workers access to CEO and vice-versa.***
- ***Encourage open-mindedness of employees to new ideas.***

Principle 32. Color changes

A. Change the color of an object or its external environment.

- ***'Corporate colors' - create a strong brand image through use of colors.***
- ***Foster employee diversity.***

B. Change the transparency of an object or its external environment.

- ***Clear, concise vision and mission statement.***

- ***Use smoke-screen misinformation to disguise confidential (e.g. R&D) activities.***

Principle 33. Homogeneity

A. Make objects interact with a given object of the same material (or material with identical properties).

- ***Hire local people to acquire cultural knowledge of local customers.***
- ***Treat employees as external customers.***
- ***Common data transfer protocols between different organizations.***

Principle 34. Discarding and recovering

A. Make portions of an object or system that have fulfilled their functions go away or modify them directly during operation.

- ***Eliminate duplicated, redundant and non value-added activities (lean manufacturing, cycle time reduction).***
- ***Reduce duplication with supplier.***
- ***Downsizing.***
- ***Using contract labor for capacity balance.***
- ***Temporary team members on short-term projects.***

B. Conversely, restore consumable parts of an object or system directly in operation.

- ***Warranty - commitment of manufacturer to repair or replace any part that fails during the life of product.***
- ***Periodically re-energize continuous improvement initiatives.***
- ***Introduce periodical re-training.***
- ***Rework of nonconforming product.***

Principle 35. Parameter changes

A. Change an object's physical state (e.g. to a gas, liquid, or solid).

- ***Virtual prototyping.***
- ***Numerical simulation.***

B. Change the concentration or consistency.

- ***Team structure change.***

C. Change the degree of flexibility.

- ***Different (individual) marketing approach for each customer sector.***

- *Customized marking, packaging, labeling, etc.*
- *Flexible, variable-sized team.*

D. Change the temperature.

- *Get customers excited about the product by giving them ownership of the change.*
- *Get employees excited about the future of the company by using full involvement strategic planning, stock options, etc.*

Principle 36. Phase transitions

A. Use phenomena occurring during phase transitions.

- *Project stages - conception, birth, development, maturity, retirement.*
- *Design reviews - preliminary, specification, critical, final, etc.*
- *Phases of QFD - organization, descriptive, breakthrough, implementation.*
- *Phases of PERT - planning, scheduling, improvement, controlling.*
- *Phases of team development - forming, storming, norming, performing.*
- *'Stages of learning - unconscious incompetence, conscious incompetence, conscious competence, unconscious competence' (W.E.Deming).*

Principle 37. Thermal expansion

A. Use thermal expansion (or contraction) of materials.

B. If thermal expansion is being used, use multiple materials with different coefficients of thermal expansion.

- *Expand or contract marketing efforts depending on the product's 'hotness' - rate of sales and profitability.*
- *Empowerment (power expansion) - authority transfer to individuals.*

Principle 38. Boosted interactions

A. Replace common air with oxygen-enriched air (enriched atmosphere).

- *Necessity is the mother of invention.*
- *'Commitment to mission' (TQM).*
- *Establish sense of urgency for need to change - the first step in transforming an organization.*
- *Obsession with customer-perceived quality, desire to delight customer ('Quality' corner of Joiner Triangle).*

- **Get customers excited about the product by giving them ownership of the change.**
 - **Periodically re-energize continuous improvement initiatives ('enthusiasm injections').**
 - **Hire highly creative individuals who understand the voice of the customer.**
 - **Build staff with high performers.**
 - **Use internal subject matter experts.**
 - **Inject new-blood/new challenge into a team.**
 - **Consider personal chemistry issues when assembling a team.**
 - **Find people who will spark-off interesting reactions with each other.**
 - **Foster mutual stimulation at brainstorming sessions.**
- B. Replace enriched air with pure oxygen (highly enriched atmosphere).
- C. Expose air or oxygen to ionizing radiation.
- D. Use ionized oxygen.
- E. Replace ozonized (or ionized) oxygen with ozone (atmosphere enriched by 'unstable' elements).
- **Venture capital.**
 - **Reengineering - radical change.**

Principle 39. Inert atmosphere

- A. Replace a normal environment with an inert one.
- **Nominal group technique.**
 - **Maintain atmosphere free of criticism at brainstorming sessions.**
- B. Add neutral parts, or inert additives to an object or system.
- **Use neutral third parties during difficult negotiations.**
 - **Invite outsider/guest to brainstorming sessions.**
 - **Introduce 'quiet areas' into the workplace.**
 - **Use time-out during negotiations.**
 - **Use rest breaks/pauses for reflection in meetings.**

Principle 40. Composite structures

- A. Change from uniform to composite (multiple) structures.
- **Combine high risk and low risk investment strategy.**

- ***Multi-disciplinary cross-functional teams.***
- ***Mix of thinking skills in a team.***
- ***Hard person/soft person negotiating team.***
- ***Hybrid audit staff - full-time employees and volunteers.***
- ***Multi-channel communication with supplier.***
- ***Combine multiple modes (newsletter, Intranet, staff meetings, etc.) for effective communication.***
- ***Introduce training with a combination of lecture, simulations, on-line learning, video, etc.***
- ***Hire Renaissance people.***

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